VEGETATION RESTORES LIFE TO COASTAL DUNES

.... rebuilds sagging economic strength of Oregon communities

Presented by

WARRENTON DUNE SOIL CONSERVATION DISTRICT
P. O Building, Astoria, Oregon

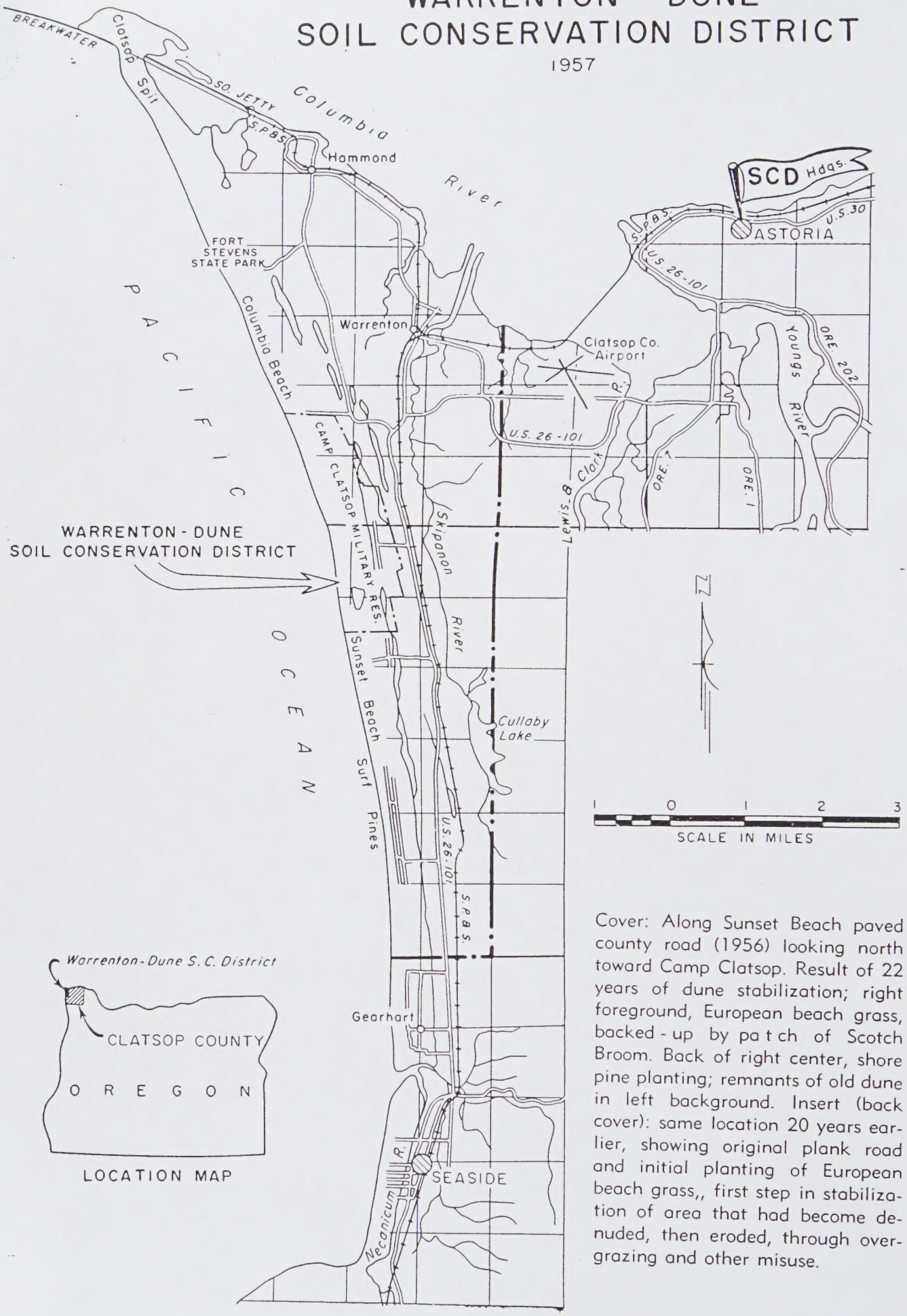
in cooperation with

CLATSOP COUNTY COURT... STATE of OREGON
PRIVATE LAND OWNERS and OTHERS, and the
U. S. D. A. SOIL CONSERVATION SERVICE

JUNE 1, 1957

WARRENTON - DUNE SOIL CONSERVATION DISTRICT

1957



Cover: Along Sunset Beach paved county road (1956) looking north toward Camp Clatsop. Result of 22 years of dune stabilization; right foreground, European beach grass, backed-up by patch of Scotch Broom. Back of right center, shore pine planting; remnants of old dune in left background. Insert (back cover): same location 20 years earlier, showing original plank road and initial planting of European beach grass,, first step in stabilization of area that had become denuded, then eroded, through overgrazing and other misuse.

SUCCESSFUL PATTERN IS DEVELOPED FOR AROUND WORLD USE

On 3,000 acres of dunes, piled up and then ripped apart and denuded by powerful sand-filled Pacific winds that sweep over Oregon's northwestern coast, Warrenton Dune Soil Conservation District has rounded out 22 years work, at the mouth of the Columbia river in establishing the pattern of a successful stabilization program that got its start as a CCC project.

Expert observers say there is nothing quite like this accomplishment elsewhere in the U. S., or in the world. In two instances in this country, one on each coast, successes have been achieved in varying degrees, but not on such an extensive and effective scale.

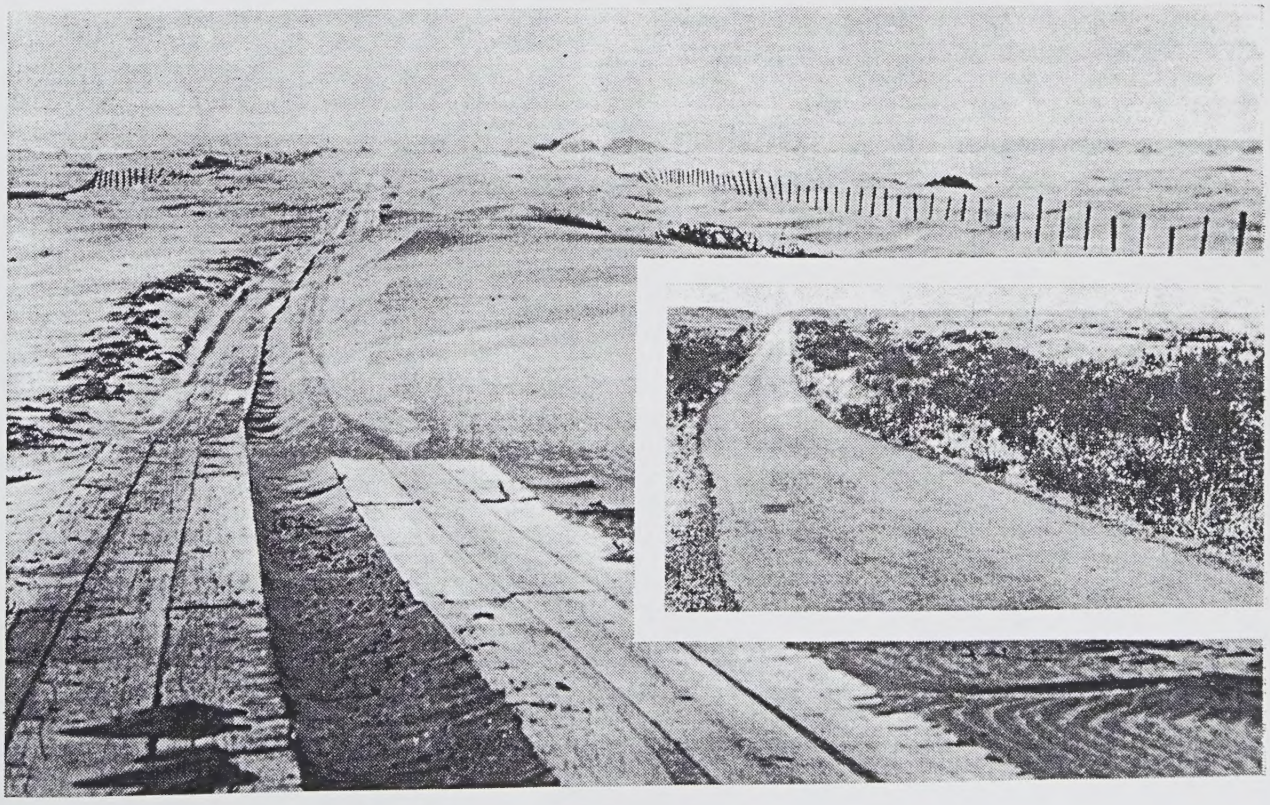
This pattern is built around one keystone practice-putting sand under a complete cover of grass, then keeping it so firmly tied down there that denuding an derosion can never again get started on another rampage and cause tremendous damage. It's so effective in establishing and maintaining erosion control, and putting wind-swept dune areas in shape for income-producing use, that it is being applied around the world in attempts to cure sore spots similar to those Warrenton had about a quarter century ago.

Three planting materials—an improved European beach grass, a shrub named Scotch broom, and native shore pine trees—have been principal performers on the dune stabilization scene. More than 200 million single plantings of these materials have been made, all by hand; many millions more will be planted before stabilization is completed on 1,500 additional acres where work is under way, or has not yet been started.

Picket fences, native grasses and legumes, and land-use regulations established by dune property owners under authority of Oregon state law, have had supporting roles. By zoning, tillage and grazing have been prohibited, and "we're going to keep it that way," Warrenton dune folks agree, because they recognize that without zoning, dune stablization would not have been achieved.

From a start at scratch on bare ground, 100 feet wide and 100 feet from high tide ,the dune stabilization pattern includes creation of a 34-foot-

Below: This is how old plank road, leading to site of present Ft. Stevens State Park beach, appeared in 1935; historic 1906 Peter Iredale wreck in center backgroun. Sand piled up and closed road, making continuous and costly maintenance necessary. Fencing, left and right, built by farmers to safeguard livestock. Insert: Identical scene in 1956, 21 years after stabilization of dunes was started. Modern hard-surfaced road annually leads thousands of visitors to park and beach.



high fore-dune that stretches 12 miles along the coast ,close to the tide's high line; so near that parts of it were washed out by several winter storms before it could get set and break up the attacks of winds and wash. Back of this front line to an average depth of 1½ miles ,like stabilization has been done in repairing breaks in old dunes and building an unbroken cover of new vegetation everywhere—on the dunes, and in valleys or troughs between them. Throughout the 3,000 acre area, erosion has been conquered. Sand has been stopped from moving inland.

From its 100 foot wide starting base, the new fore-dune has spread to a 350-foot wide foundation. Most of this expansion is on the windward side. Up that face, toward the Pacific ,and on over the top, it presents a thick close-knit cover of grass which is strong enough to turn back the heaviest onslaughts of wind and sand and give the soil complete protection. On the lee side, grass, trees and shrubs team-up in like resistance.

Beach grass—what Holland has long used to protect its famous dikes—has always played the leading role in rehabilitation of the dune area. At Warrenton an improved strain was developed at a dune nursery, established by Soil Conservation Service to produce planting stock. Started as a 4-acre experimental area, producing a few hundred thousand plants per year, it grew into a 40-acre operation, producing 20 million plants annually, before it was abandoned in 1948. The initial planting stock for experimental use at this nursery was obtained from Coos Bay, Oregon, where an exploratory stabilization project had been launched on a small area.

Beach grass is the star performer because it likes sand; the more it gets, the better it grows. A complete covering of fresh sand is just like a good meal, because the beach grass quickly pushes its way right up through the compact blanket and becomes stronger and better through this exercise. When it is piled up on beach grass, fresh sand acts just like a stimulant. Without this boost from sand, beach grass plantings die, unless fertilized.

The chief value of beach grass is in its quick development as an effective cover crop. It lacks feed value because livestock simply will not eat it. The planting season starts in October and continues until May or June, when weather becomes warm. The growing season starts with planting and continues through August or September. Then, after a short season rest, new growth begins and soon pokes its head through the mass of the previous season's crop. Growth always is strongest and fastest atop dunes and on the windward side. Plantings are made at 18-inch spacings, in clumps of 3 pieces of 18-inch stock of which at least 8 inches remain above ground. Growth is mature at about 3 feet.

Scotch broom and shore pines serve best when planted in the Soil Conservation Service land-use capability pattern—trees on steeper slopes where they will thrive and where grass would have terrific difficulties in developing strength, and trees and shrubs on rough and hard-to-handle areas where grass doesn't do well, but good wildlife habitat can be produced. Scotch broom grows to a height of 6 or 7 feet before it is fully developed. Shore pine matures at about 50 feet.

In early plantings in the dune area, grass, shrubs and trees were inter-mixed about everywhere. In recent years this practice has been abandoned and land-use capabilities have become the guide. In tree and shrub plantings ,survival has been very high. Tree failures were among species not suitable to the climate.

Trees do the best stabilization job when they are planted in blocks, a system that opens the way for fire lanes. Block plantings have been made in about half of the 3,000 acre area. Since 1954 plantings of shrubs and trees have been temporarily discontinued because flow of planting stock stopped when SCS nurseries were closed. The only current source for these planting stocks is through purchases by land owners from comercial growers. At the start, under the original CCC program, planting stock and planting labor were received from government without cost to the property owners. From government sources, when the SCD took over, property owners continued to receive planting materials without cost, but each individual paid for the planting labor used at his property. It is believed that stocks for work yet to be done can be obtained from SCS plant material centers which have been put in operation at former nursery sites.

Originally, picket fences, usually set in two parallel rows 30 feet apart, with pickets one foot below and 4 feet above ground, were used to help create the base for the new fore-dune and to mend breaks in old dunes. Sometimes, when building of the base had been started, fencing was lifted part way out of its original position so height of the base could be increased. The chief function of fencing was to catch and confine sand and create a solid, smooth surface where beach grass could get a good start. Likewise it helped prevent damage by incoming tides. Now, fencing is used only where there are special problems because of lay of land. Elsewhere, vegetation alone will meet all needs.

Before the practice was found to be unnecessary except in unusual situations, considerable use was made of picket fences. Twenty three miles were built with material hand-carried to the beach because roadways for vehicles didn't exist. Likewise, other planting materials and tools were moved to areas of use.

As a finishing-off process, particularly in valleys between old dunes and on easy slopes, after stabilization has been accomplished, native grasses and leugmes, when drilled into beach grass and fertilized have become highly effective in giving protective cover a stronger upper-hand in sapping the destructive power of wind-blown sand. They make a ranker, denser and tougher growth than

beach grass and crowd it out of the picture. They are palatable, and livestock will eat them, but will not eat beach grass.

Warrenton Dune SCD is the first in the state to invoke use of the land use regulation provision in Oregon's soil conservation district law. Through a 1948 referendum, as provided by this low, at least three-fourths of the votes cast, representing at least two-thirds of the land ownership in the area, were favorable in authorizing Warrenton Dune SCD to protect 5,864 acres by zoning. Two zones were created. In one, grazing, tillage and construction of buildings are prohibited. In the other, grazing and tillage are prohibited, but construction of homes and creation of recreational facilities, with limitations, are permitted. The area is about evenly divided between these zones.

Launching of the original 3,000 acre stabilization project came about as a result of serious threats that galloping sand presented to welfare of coastal communities along a 15 mile front, and to an average depth of 1½ miles, which constantly was becoming deeper. Beaches and resorts were being damaged. Columbia River ocean shipping lanes, highways, roads and other avenues of travel were being filled with sand, and continuation of state and federal military establishments was menaced. Homes and other buildings were damaged and destroyed and further use of summer homes and cottages was imperiled. Sand was filling-in lakes and wooded areas. Crops were wiped out, livestock was threatened, and there was rapid climbing in the amount of tax delinquent property. At least 3,000 acres were not producing any taxes.

Before early 20s, in valleys between dunes and on easy slopes, grass, top-flight in hay and forage qualities, "grew as high as a horse's belly". Farm livestock licked their lips in these lush pastures, and were the basis of a profitable industry. All of the trouble that followed started with overgrazing and other misuses of land, and the construction of a jetty on the south side of the Columbia river. These acts brought on wind and water erosion that denuded the soil or built out additional land that previously had not been covered by vegetation.

While a small dune stabilization activity had been conducted on an experimental basis at Coos Bay by army engineers and the navy in 1926-28, and in 1934 by Forest Service at Siuslaw National Forest, south of Reedsport, another Oregon coastal town, the program launched at Warrenton was the first to get started on a large scale along the west coast to elsewhere in this country.

Success achieved at Warrenton Dunes has attracted attention where like problems exist in this nation. Many foreign countries have sent official representatives to study the system, and shipments of planting stock for experimental work have been sent to those areas. Overseas visitors have come from Iceland, England, Mediterranean, Middle East and North and South Africa countries, India, New Zealand and the Philippines, as well as such good neighbors as Canada and South American nations.

Development of the project started with obtaining establishment of a Civilian Conservation Corps (CCC) camp at Warrenton in 1935 for the one specific purpose. The labor force consisted of 150 youth working under direction of foremen and Soil Conservation Service technicians. It was a start from scratch venture because no successful means of attack had ever been developed. While there were some ideas as to what materials might be required, selection of these materials was still in the questionable stage. About the only 'sure thing' was existence of a dangerous problem that had to be handled as quickly as possible.

CCC carried through experimental work and got the plan of attack pretty well established before it went out of existence in 1941. Warrenton Dune Soil Conservation District was set up to take over when CCC dropped out and, with the continuing technical assistance of Soil Conservation Service it has kept the work moving toward its successful conclusion.

Looking back over the 22 years work with the dune problem, community leaders, who have worked with the project from its inception, cite these particular benefits, among many that have accrued:

Broadening of the tax base by opening way for safe construction of homes and business places and establishment of recreational facilities for use of year-around, summer and vacation people, all of which has created constantly increasing community income;

Protection of Columbia river shipping lanes, state and county roads and highways and other routes of travel, bringing deep cuts in heavy annual maintenance costs;

Removal of menaces to Fort Stevens and the 1,700 acre Camp Clatsop, military establishments of the U. S. and state governments;

Establishment and expansion of the 750-acre Fort Stevens State Park which attracted 170,000 visitors and 9,300 campers in 1956, as a recreation center offering salt and fresh water bathing, water sports, fishing, boating, picnic areas and over-night camps;

Opening of way for recovery of good agricul tural land and restoration of forage and other crops through application of soil and water conservation practices, such as drainage that will permit cropping of water-logged acres, long out of production.

Development of 250 acre game p r e s e r v e, stocked with game birds by Oregon State Game Commission, with restricted hunting; over-all creation of wild life habitat, and launching of new dune area housing developments, one of which includes 17 residences having an average valuation of $25,000.

Last year, when 8,000 more acres were added to the SCD's area, it put anothe 1,000 acres into the dune program. The current stabilization schedule calls for completion of work on the remaining

Above: In 1937, remnants of original fore-dune extended parallel to ocean front (from lower left). "Potholes" had been gouged out by wind and sand, and gaps had been cut, allowing sand to invade and cover lush meadowland. It piled into Sunset Lake, damaged resorts and Columbia and Sunset beaches and threatened National Guard camp (white rectangle, upper right). Between original dune and ocean, new fore-dune is being started for stabilization of area. Part built without using picket fences, only beach grass. Stream in right background is Columbia river; ocean at left. It was across this narrow neck of land that winds were piling sand into the Columbia, threatening to cut off navigation.

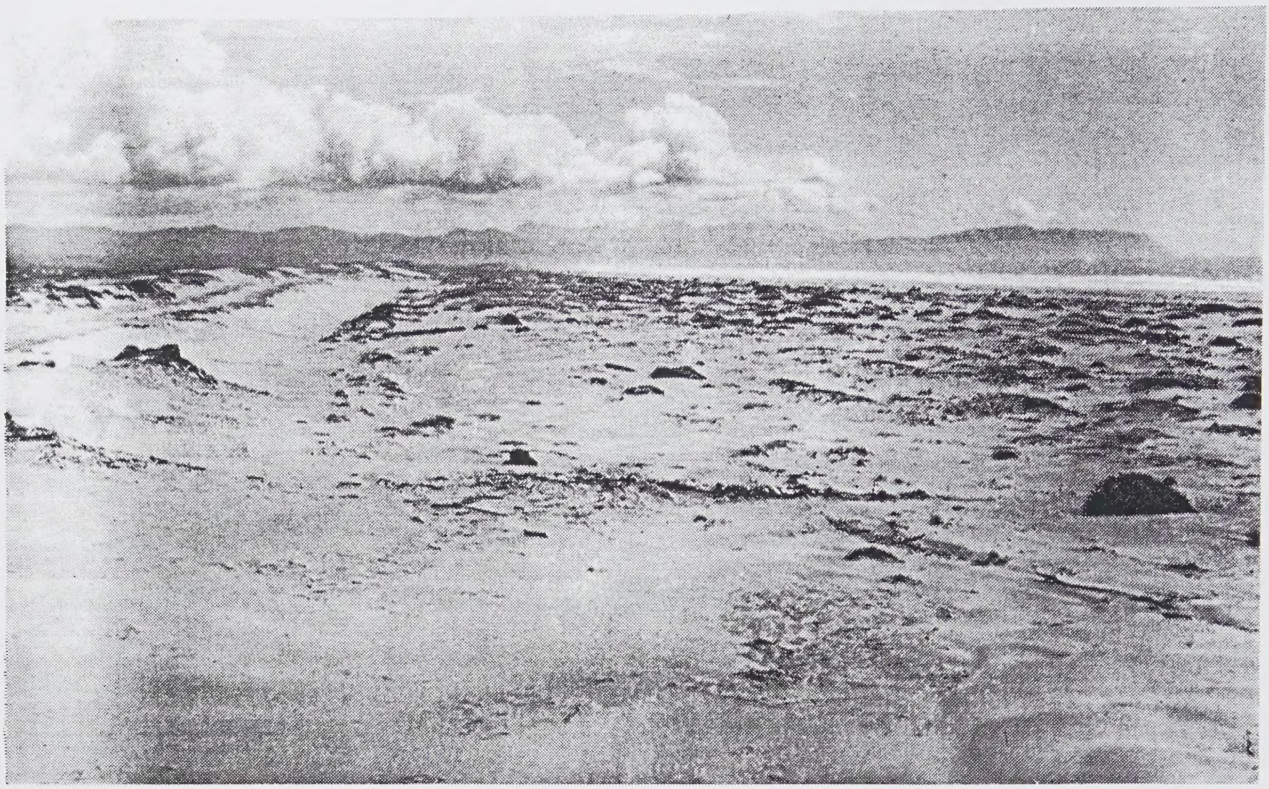
1,500 acres during the next 5 years. On most of the 500 acres left in the original project, stabilization is well under way.

Scope of the sand problem faced 22 years ago is indicated by such developments as finding an original survey corner stone buried as deep as 37 feet under wind-blown sand. Benefits are indicated by restoration of vegetation in the valleys and on easy slopes, where the grass is again almost as "high as a horse's belly", and gives indications of going even higher.

Restoration of that type of cover has come about because Old Mother Nature has lent a helping hand by providing native grasses and legumes which, when drilled into the beach grass, crowd it out of the cover. These children of Nature have served as reserve troops which she rushed into the battle when the shock troops — European beach grass, Scotch broom and shore pine — had done their jobs. Mother Nature sure can raise a heck of a lot of trouble when here children are abused, as in the early 20s. She can help wonderfully when friends come to her aid, like the CCC folks and the Warrenton Dune SCD people, and the SCS technicians and other cooperators, have done during the last 22 years.

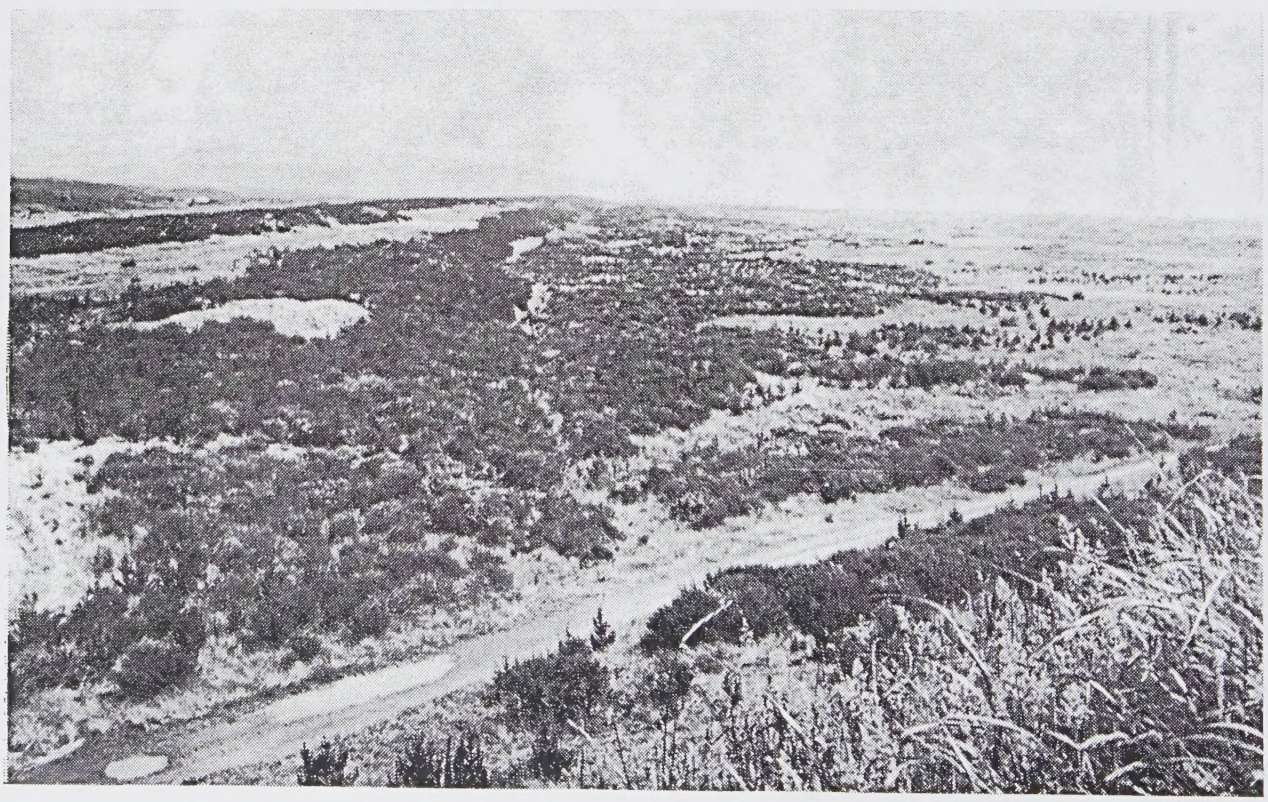
Above: Here is how new fore-dune, protected by picket fence, looked in 1937, a year after it had been started. It's ready for planting of European beach grass. Some plantings already made in back areas. In background, to right of men, sand hummocks have developed naturally because sand, carried by wind, clung to beach grass.

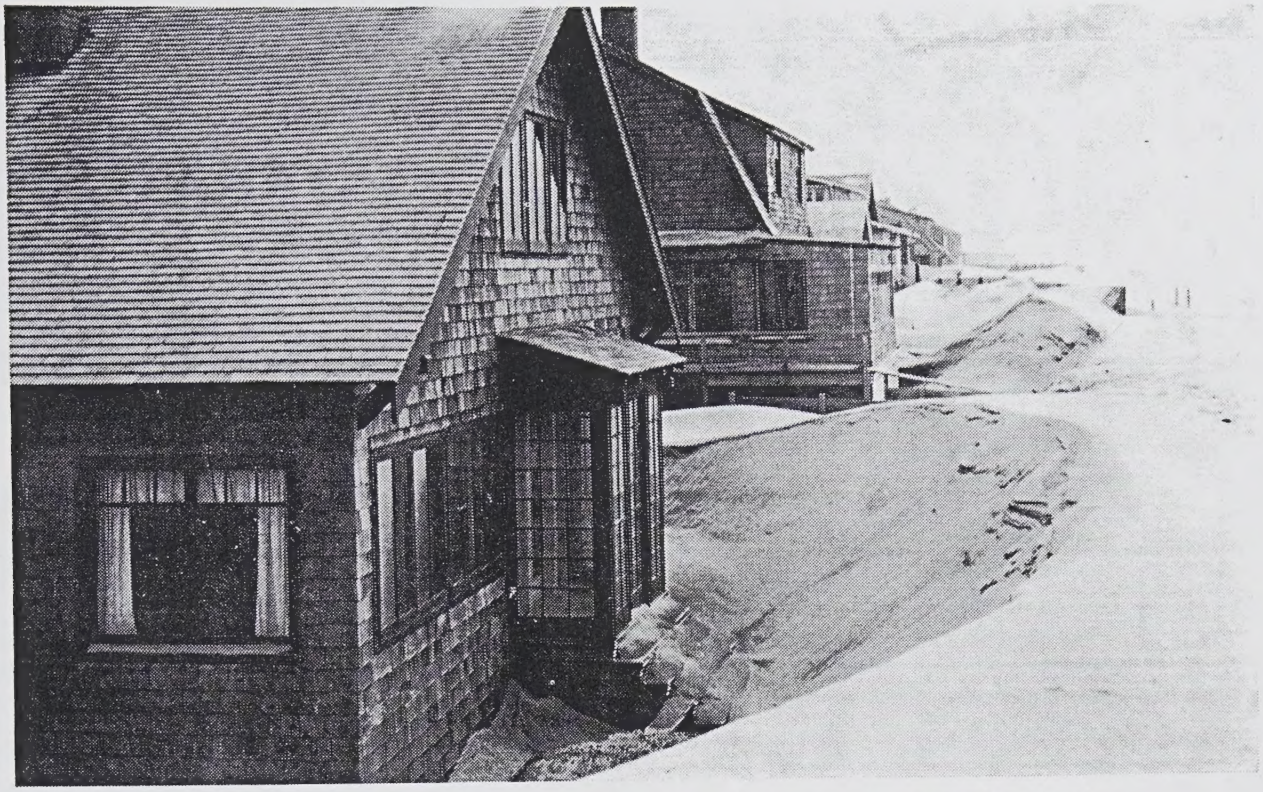
Below: Twenty years after new fore-dune was started, this is how it looked (1956). It is the freshly started fore-dune pictured on preceding page. On lee side, natural nativ grasses and legumes have been brought in by Mother Nature to help establish strong cover. Native legumes work like nitrogen fertilizer in speeding development of cover; supply good feed for wildlife.



Above: In Delura Beach road area, remnants of old plank road leading to beach have been scattered by wind. Back of wreckage is Camp Clatsop property.

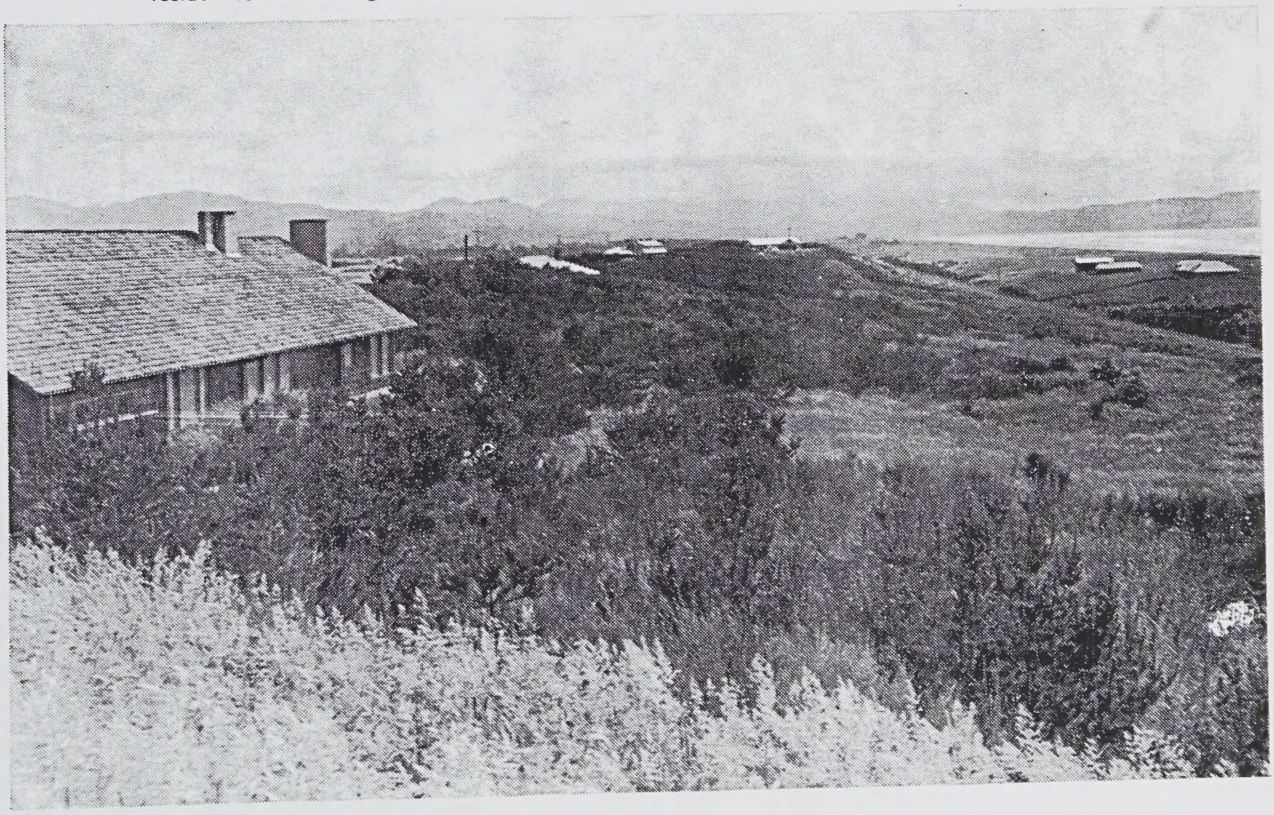
Below: This is how same area appeared in 1956. White spot, center left background, is main building at Camp Clatsop. In foreground is Delura Beach road. Shrubs are Scotch broom, interplanted with shore pine, now about 6 or 7 years old.





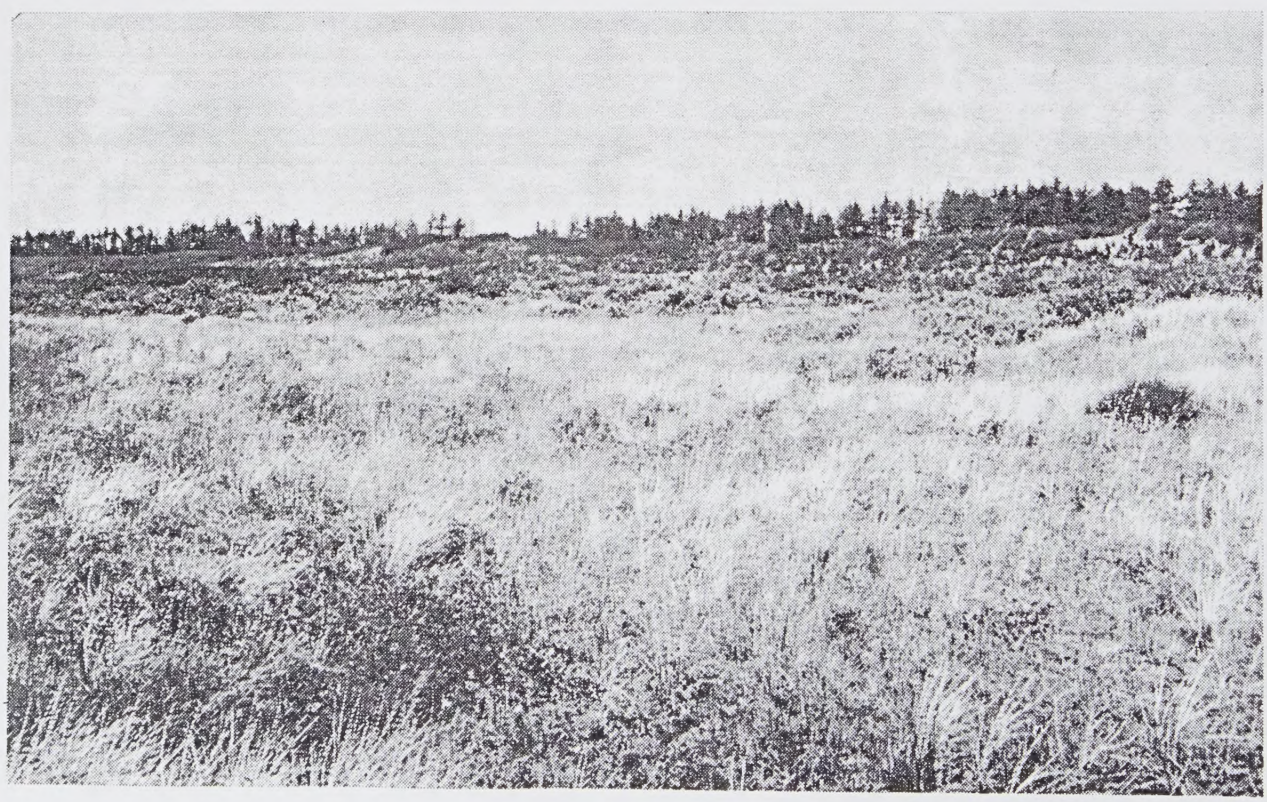
Above: Winds and sand caused troublesome problems for home owners and renters in areas in southern part of district, where there were concentrations of such buildings. Sand piled up to height of second floor of residences, blocking leaving or coming. Heavy expense was caused in removing sand, sometimes several times a year. Picture in Gearhart area in 1935.

Below: With stabilization of dunes, modern new houses are built. Here is part of Surf Pine development on top of dune overlooking beach. It was started in 1947 and includes 17 residences with average value of $25,000.



Above: This is how an area west of present Ft. Stevens State Park appeared in 1937. Between barren sand area in foreground, and native woods, there is a grass planting. Coffenbury lake lies back of trees. Sand blasts were taking out some trees and covering others, creating gaps through which sand swept to threaten usefulness of lake. It was area of desolation.

Below: By 1956 stabilization had produced a scene like this in identical area. Lower picture on preceding page illustrates same treatment that this area received. European beach grass, into which native grasses and legumes have been drilled, is in early stage of development. There is about 2 or 3 years differenc in age of this development and that in lower picture in preceding page.



Above: On county property, north of Columbia Beach road, here is a 6-weeks old European beach grass planting. Sand piling up around base made each clump an individual barrier. Insert: After CCC boys left, men and women took over planting, all done by hand.

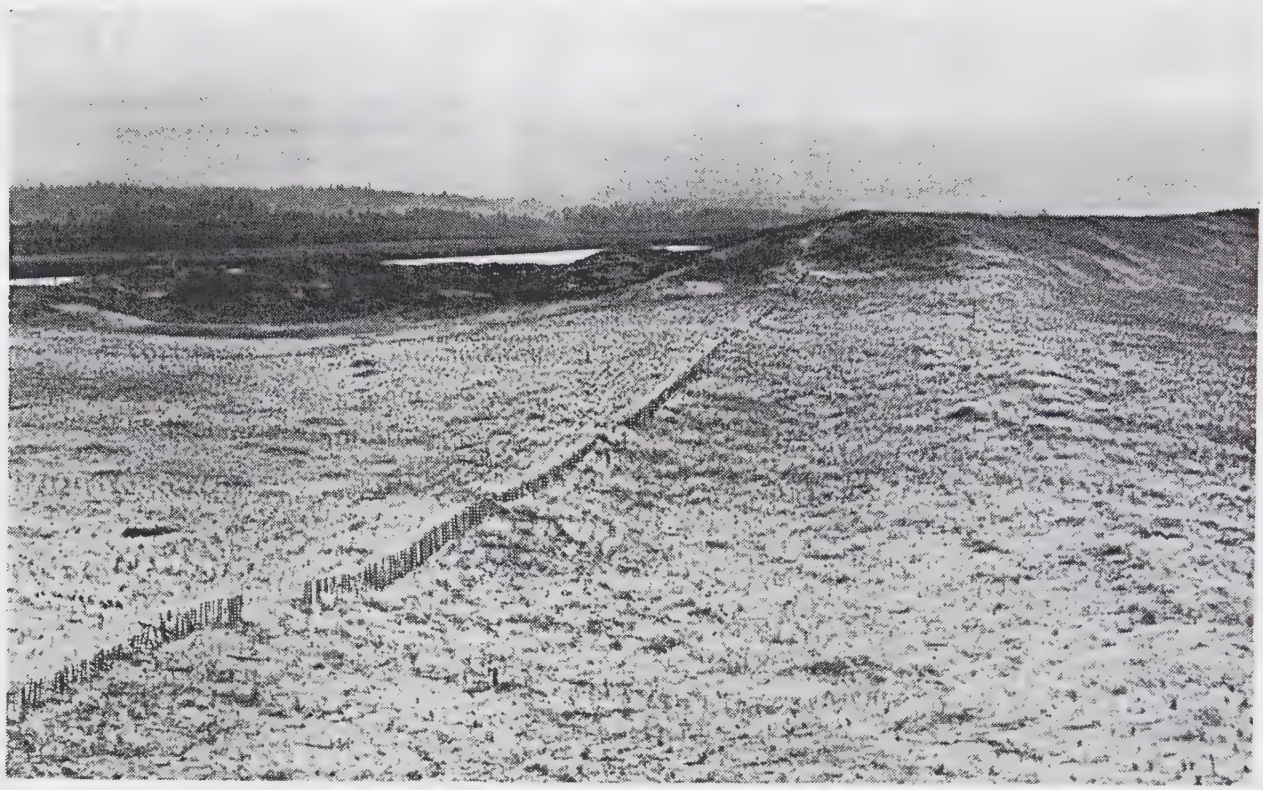
Below: Here is what had come out (1956) of this identical planting. When beach grass had developed, native and imported grasses and legumes were drilled into new cover and fertilized. In continued development of excellent cover like this, original beach grass disappears. In 1956, cover on valley floor looked like original growth before overgrazing, misuse and windblown sand wiped it off face of earth.

Above: In this roadless area, as it appeared in 1937, the army, during World War II, built a gravel road leading to control station or lookouts between Ft. Stevens and Camp Clatsop. In starting stabilization of area, CCC boys packed planting stock in on foot. Sand is piled up on former level areas. Remnants of original dune in central background; trees in background mark site of present Ft. Stevens State Park. In this level area there once was luxuriant grass, with no wind erosion.

Below: Here is identical site, with new gravel road built by military services. Beach grass and shore pine plantings appear in foreground.

Above: Here is one way that erosion got started. Unrestricted livestock, wandering over dunes, cut sod and made paths which gave winds, sand and water chance to blast and wash the cover away. Zoning stopped this trouble making. Insert: This is kind of damage that cow paths and other breaks in cover led to about 1920.

Below: When things such as this happen in the newly stabilized area, the door to destruction of cover is again wide open, and years of stabilization work can be wiped out. This damaged spot is near Ft. Stevens Park. To rebuild break, stabilization workers must start back at scratch.



Above: This 1938 view is south of Sunset Beach Road, with Sunset Lake in background. Cow path, like on preceding page, started erosion that led to destruction of ground cover. Wind, breaking down original dune, allowed sand to pile through and damage or destroy homes, woods and pasture. Fence indicates type of barrier used to stop cutting wind and protect property back of it while plantings of beach grass and trees were developing. Below: Here is the identical area in 1956 after shore pine had taken over and become effective barrier against wind blasts.

Above: This was taken in Peter Iredale road area, west of Coffenbury lake, in 1935. Shows how sand was working way through wooded area blasting trees and threatening use of lake. In this area, Ft. Stevens State Park has been developed.

Below: Barren sand area, in 1937, just south of Hammond Beach road. Double row of picket fence, extending toward left foreground from road (across top of picture) was built in 1935-36. Oblique fences, built at same time, protected "Alders" picnic center (at right) where portion of grove already had been destroyed. This mechanical means for establishing control was one of the trials used in testing materials and methods, and was abandoned in favor of vegetation with fertilization, which produced desired results more effectively and economically.

Above: CCC boys fertilizing native grass and legume plantings, directly south of Peter Iredale road at north end of Coffenbury lake, site of present Fort Stevens State Park.

Below: Same site as in picture at top of this page; showing how people from all over the country flocked to Fort Stevens State Park in cars, busses and trailers in 1956 to enjoy wide variety of vacation and recreational activities.

Above: Extreme northwest corner of SCD, showing Columbia river in background, Pacific ocean on left, with Coffenbury lake, headwaters of east Neacoxie drainage project. Continued recreation area to be carried on by state parks, more picnic and overnight camp sites will be developed around Coffenbury and Crabapple lakes seen in background where pictures on preceding page were taken.

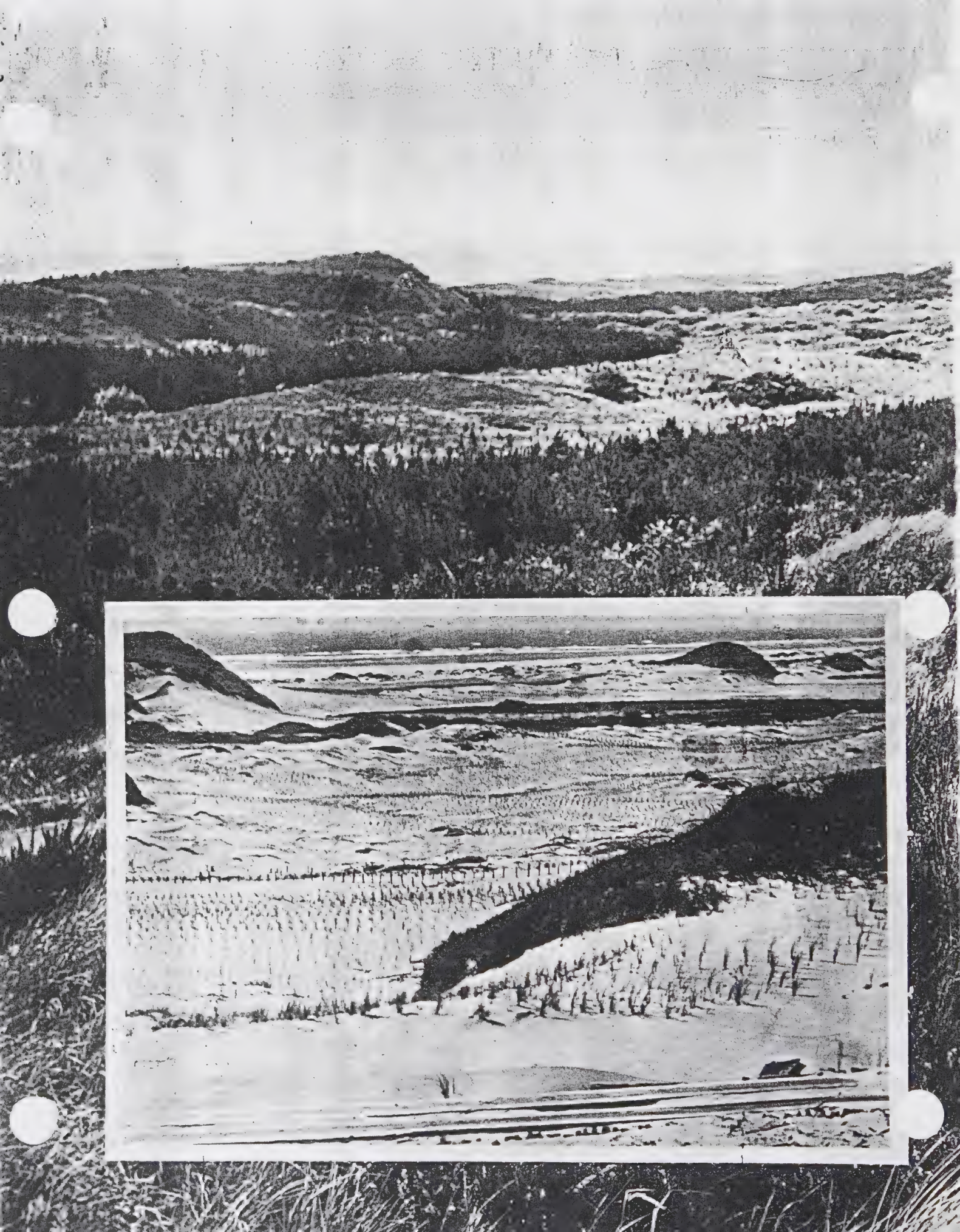
WAY CLEARED FOR NEW SOIL AND WATER CONSERVATION WORK

The situation at hand, after 22 years of work in sand dune stabilization, points up two specially important lines for future activity: (1) completion of the whole establishment job, in the original district and in the recent 8,000 acre addition, within the next 5 years, and (2) further development and more alert application of the maintenance program.

We would have been farther advanced in completion of the project if availability of planting stock had not been curtailed and in some instances entirely shut-off for long periods. Restoration of Soil Conservation Service plant material centers, we expect, will be helpful in stabilizing flow of planting supplies to our dune work program.

Maintenance work has been developed as the eration has progressed. Generally it has been fective, but in a few instances there have been difficulties, and threatening breaks in the dune cover have occurred. It is important that these breaks be detected and remedied before great inroads have been made in protective plantings, and that action be taken to prevent a recurrence, whenever it is possible. This calls for more frequent and more careful area-wide checking. A system for handling this problem has been carefully developed and will meet the needs, if we keep our eye on the ball.

There also is need for another item in maintenance — the protection that is afforded by creation of fire-breaks in wooded areas. Nearly 20 miles of these fire-breaks have been established, and a lot more are needed. Most of the earlier plantings are entirely without fire-breaks. This creates a tremendous hazard. Fire-breaks are included in the more recent plantings. Application of these protective measures was delayed at the start because of a lack of information on time required for development of woodland, and data on survival of plantings of varied species.



Fort Stevens Review

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Friends Of Old Fort Stevens,
Helping to preserve the history of Fort Stevens State Park

Spring 2005 Second of three issues for 2005, Winter, Spring, & Summer

Some readers may not be aware of this, but adjacent to Fort Stevens State Park is an U.S Army Cemetery which is managed by an office at Fort Lewis, Washington State. For a number of years now, FOOFS has had the contract to take care of the cemetery, including arranging for burials. FOOFS board member Jack Bentley, pictured above, takes care of all the details, and is credited with doing an outstanding job. His work is appreciated by the families whose loved ones rest there, and by FOOFS for making the contract possible.

Saga Of The Fort Stevens 12" Railway Mortars

As told by
D. Lindstrom

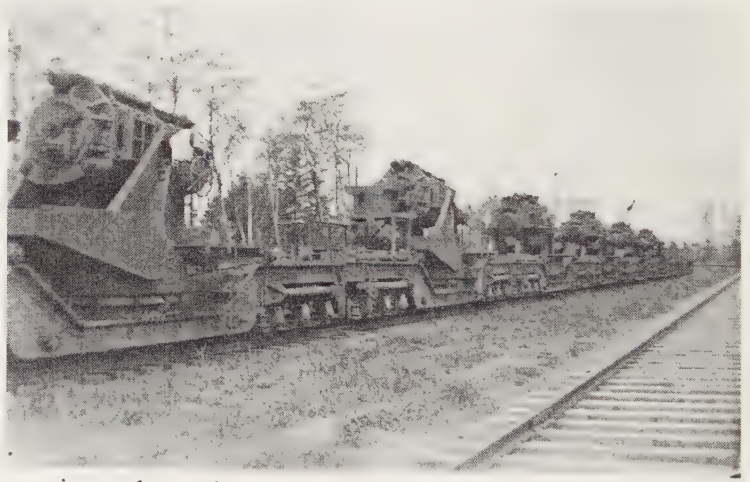
Anyone who has looked through the photos at the Fort Stevens Military Museum may remember seeing several depicting mortars mounted on railway cars. Maybe there is still a veteran or two who remembers seeing them. In the photos they seem to be sitting off by themselves, largely forgotten, and at best a curiosity. Why were these weapons at Fort Stevens? Were they ever used?

Recently a manuscript surfaced that provides some of the answers. Warren A. Starr wrote it after the war. The unfortunate part of his story is that after his stay at Fort Stevens he ended up in the Philippians and was captured by the Japanese. The good part of his story is that he survived the tortures of the prisoner of war camps.

As for Fort Stevens, Warren's story begins when he was ordered to active duty as a Captain and reported to the fort on May 5, 1941. In the meantime, finding housing for his family was difficult, but eventually they were able to settle in Warrenton.

He was put in command of Battery B, 18th Coast Artillery. Upon receiving his assignment, he was ordered to install a field location for four of the12" railway mortars and conduct a practice firing, all within thirty days time. In finding out more about them, Captain Starr discovered that after residents of Washington and Oregon coastal areas complained to their congressmen in 1935 about 150 miles of unprotected beaches, the Army brought in these eighty eight ton 12" inch railway mortars and sat them on a spur track at Fort Stevens. There were eleven legal sized sheets of paper, single-spaced; giving lists of ordnance equipment that went with these guns. Examples were numerous large and small tools, track laying equipment, railway gauges, peavies, mauls, etc.

Battery B consisted of 160 enlisted men from Ohio with three months active duty training. They needed a quick education in the ways of railway mortars. These guns were intended to have a complete train, including an engine, ammunition car, gunnery control car, and a command car; none of which existed. Furthermore, the guns were designed to load from the adjoining railroad ammunition car, not from the ground. These guns had not been fired since the initial proving ground shots at the Waterveleit Arsenal where they were built. The only entries in the gun record books were notations about the annual inspection of the air brakes on the railway cars.



Carrying out orders was mind-boggling. A one half mile of railroad spur, off of the Corps of Engineers Columbia River South Jetty Project railroad, had to be built among the sand dunes of the Columbia River estuary. Once the spur was completed, four guns were to be located there. Platforms had to be constructed from which to load the guns with ammunition, a fire control system had to be

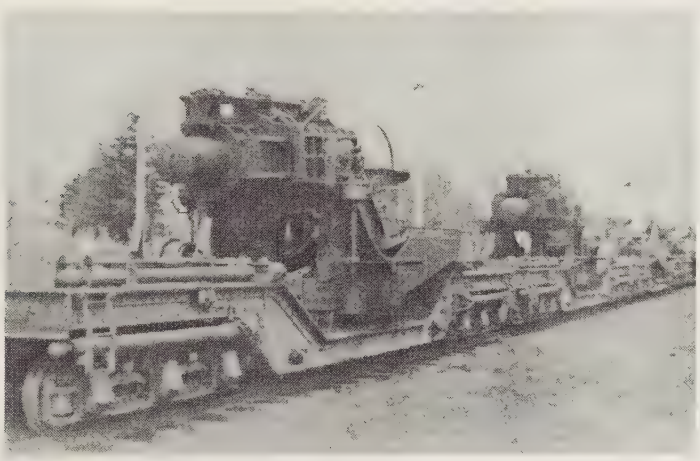
developed, and the guns had to be camouflaged. Another part of the assignment was to calculate how to move the guns. Starr found that it would cost $500.00 for the SP&S railroad to do the job, but the Army refused to pay. The Corps of Engineers had no engines to loan, as they were leasing service from SP&S. So, Battery B resorted to blood, sweat, and tears.

Captain Starr and his men built the one half mile spur. They "borrowed" ties, rails, and hardware from the Corps of Engineer's jetty project line. Then, using rail peavies and one and a half inch rope hawsers, and 160 men on the lines, the guns were moved about one and a half miles, one at a time, by human power, and spotted on the spur line for a target practice. For fire control, a Cloke plotting board, usually used for the 155 caliber guns, was improvised. They created their own triangulation and tracking equipment. Now these were CAN DO guys. Camouflaging the guns and the spur line was a huge problem. After several attempts, 2x4 frames, hinged to fold back, and draped with discarded fish net, were made to work.

Remarkably, this work was accomplished and the target practice was fired within the thirty-day limit as ordered. After the firing practice, the railway mortar battery in the sand dues of the Columbia River estuary was maintained for a short time. After Captain Starr and others were transferred to the Philippians, the position was turned over to one of the battery Lieutenants. Soon thereafter, the guns were moved back to their original resting place on the Fort Stevens spur.

Epilogue. When World War II broke out, there were eight 12" railway mortars at Fort Stevens. In January of 1942 four were taken to Brown's Point, at the north entrance of Gray's Harbor, located approximately fifty miles up the coast in Washington State. Then during February 1942 the remaining four were moved to Fort Lewis near Tacoma, Washington.

Battery C, 249th Coast Artillery, was transferred to Brown's Point with the railway mortars. They traveled by truck, while the mortars and the ammunition went by rail. Once the mortars arrived at the City of Aberdeen, located at the innermost part of Grays Harbor, they were barged to Brown's Point.



Rails were laid there to accommodated the mortars. Ken Bromwell, a gunner with Battery C, recalls that their living quarters were dug into the ground beside the mortars and covered with earth. He also remembers the food. Oh the food. Once, they received frozen reindeer meat from Alaska. It looked bad, smelled bad, and tasted bad. Then arrangements were made with a local farmer. If one of his cows "accidentally" got shot, the mortar boys agreed to pay for his loss. Then the cooks would retrieve the remains and cook up a feast. It wasn't long though before the Army found a way to stop the fun. The cows didn't meet Army sanitation requirements.

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☆ **Civil War Reenactment Labor Day Weekend**

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The above is a new logo for Fort Stevens. We are putting it on mugs, T-shirts, and caps. It has a field of deep red with yellow gold features. It's really quite striking. We hope you will like it. It was developed by a local artist and the Review editor.

THE CCC'S

Some readers know how all the trees and some aspects of dune stabilization came to be in and around Fort Stevens. It was due to President Roosevelt's CCC's, or Civilian Conservation Corps. They came to Fort Stevens in 1935 and were housed in several one story bunk houses near the mine loading dock. In 1937 the CCC's left, and during part of the war years anyway, a few soldiers and their wives lived there. The site can be seen today behind the laundry foot print where several Coast Guard towers are located.

FOOFS President Ron Kinsley, Oregon Parks Assistant Area Manager Mike Stein, and the FOOFS board greatly appreciate your support. If you visit the museum, please let the hosts know that you are a FOOFS member and if you served in the Harbor Defenses of the Columbia

Inside photos are from the FSSP Military Museum collection.

Reprinted from "Coastal Zone '87"
WW Div./ASCE, Seattle WA/May 26-29, 1987

STABILIZATION OF WEST COAST SAND DUNES

by
Frank Reckendorf[1] Don Leach[2], Robert Baum[3],
and Jack Carlson[4]

ABSTRACT: Control of dune activity and the introduction of European beachgrass have generated far-reaching effects on the West Coast landscape. Between 1900 and 1935, a series of small sand stabilization projects were initiated on the West Coast utilizing European beachgrass and various species of shrubs and trees. In 1935, the Soil Conservation Service (SCS) and the Civilian Conservation Corps (CCC), at the request of local landowners and city and county government, began a comprehensive sand stabilization project on the Clatsop Plains in Oregon called the Warrenton Project. Some 1215 ha (3,000 ac) of actively blowing sand were systematically stabilized in a progression which essentially duplicated natural plant succession. Artificial barriers and resistant grasses were used to still the sand and begin the formation of the dune. Scotch broom and other legumes were added to fix nitrogen and provide cover and organic material for later plantings of shrubs and trees.

The techniques and procedures learned in the Warrenton stabilization effort were applied throughout the West Coast utilizing the same or similar plant materials. Other stabilization projects occurred in places such as (1) the Grayland and Ocean Shores areas in Washington; (2) the Seaside, Pacific City, Tillamook, Lincoln City, Newport, Waldport, Florence, Gardner, and Coos Bay areas in Oregon; and (3) the Bodega Bay, Morro Bay, and Santa Maria areas in California. A total of about 4,000 ha (7,900 ac) was stabilized by these projects.

INTRODUCTION

Thousands of hectares (ha) of sand dunes have been stabilized along the shoreline of the west coast of the United States. This paper describes 26 sand stabilization projects that have been implemented in the last 75 years.

There are two major sources of sand that form coastal dunes: erosion of coastal formations by waves and the sediment from rivers. Ocean currents move the sand from eroding headlands and the mouths of rivers to indentations along the coast. Sand deposited on the beaches is exposed at low tide, dries quickly, is caught by the wind, and carried inland to form dunes. Vegetation established on the sandy surface adjacent to the beach, entraps sand, which accelerates dune formation.

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Dunes or dune landscapes can be classified and described in several ways which are important to their stabilization. Some background information concerning the configuration of dune forms is presented in Fig. 1.

The greatest amount of sand movement along the West Coast, particularly on the North Pacific Coast, takes place during the high-velocity wind storms in winter. During these storms sand engulfs the vegetation near the beach. In spring and summer vegetation grows up through the sand and forms a lush cover. The vegetation is covered again the next winter and a continuous sand ridge forms layer by layer which extends, without interruption, parallel to the coastline. This (recently formed) barrier ridge along the beach is called a foredune (see Figs. 1, 2 and 3).

Open dunes (Reckendorf 1975) are very important for recreational use as evidenced by the popularity of the public, Bodega Bay dunes in California, and the Oregon Dune National Recreation Area in Oregon. However, stabilized dunes are necessary to (1) protect other natural features, such as lakes, wetlands, forests, and estuarian habitats along coastlines; (2) protect improvements such as highways, parks, shipping channels, and urban development; (3) create and maintain sheltered wetland or upland habitat for wildlife; and (4) provide access to beaches for recreational use. The experience of landowners teaches us that unstabilized dune areas, subject to wind and water erosion, are potential threats that may extend for long distances inland. Small "blow-outs," varying from a few square meters to several hectares, are often the inconspicuous forerunners of large, active sand areas unless immediately controlled.

Many large, active sand dunes have been stabilized along the Oregon, Washington, and California coasts since the turn of the century (see Table 1). Most (about 4500 ha) of the dune stabilization projects have been in Oregon, which, in the early 1900's, had the largest area with unstable dunes. The spread of European beachgrass (Ammophila arenaria) (L.) Link), which was used in almost all stabilization areas, has also enabled thousands of hectares of dunes in Oregon, Washington, and California to stabilize naturally. About 7000 ha of open sand dunes (essentially unstabilize) remain along the Oregon Coast.

A summary of the large stabilization projects emphasizing those carried out with assistance from the Soil Conservation Service (SCS) and soil and water conservation districts are shown in table 1. Many businesses, institutions, units of government, and state and federal agencies have been involved. Some of the more significant dune stabilization work will be discussed in detail, starting with Oregon, where most of the techniques and procedures used in the west coast were developed in the late 1930's.

OREGON

Some of the earliest stabilization work on the West Coast was done by the O.N.&R. railroad between 1897 and 1899 adjacent to the northern end of Seaside, Oregon (Lackenby by 1937). In 1935, the SCS in Clatsop County, Oregon started the Warrenton Dune Demonstration Project, one of the most complete and extensive stabilization efforts on the West Coast. The blowing

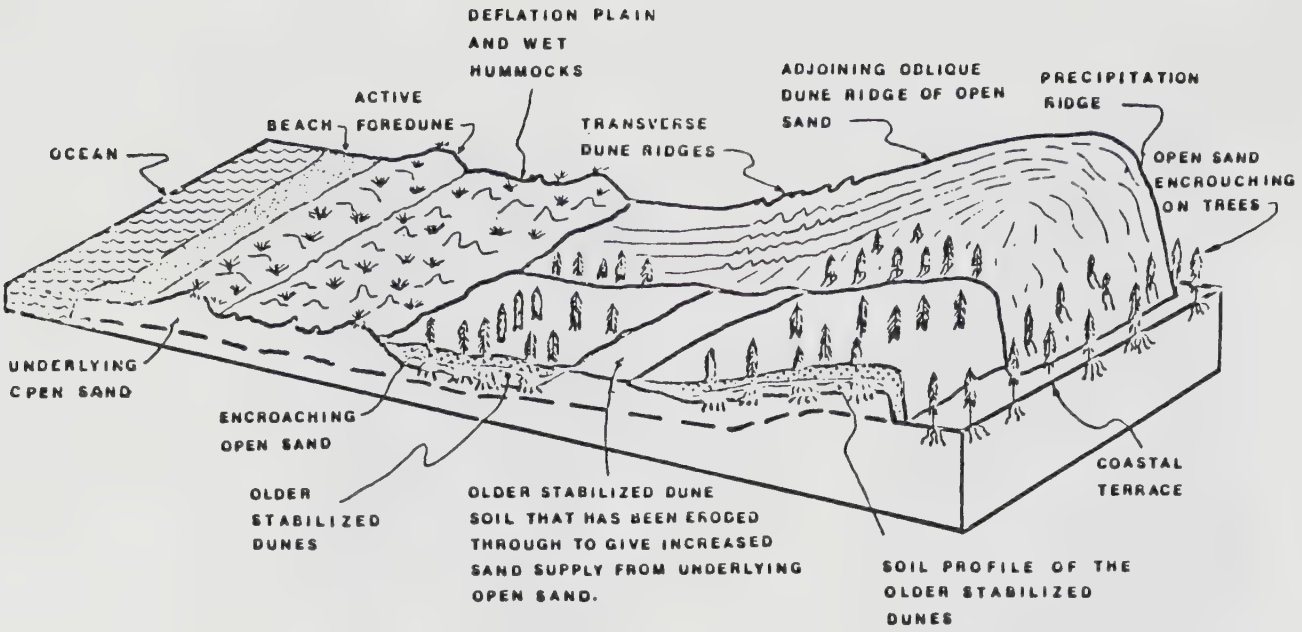

FIGURE 1- GENERALIZED SAND DUNE PROFILE

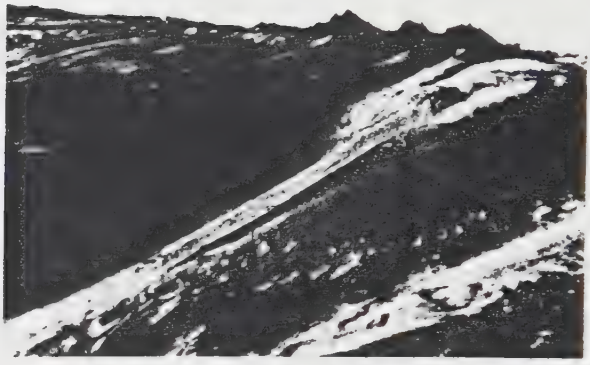

Figure 2 - Active foredune west of Siltcoos Lake in Lane County, Oregon. Photograph shows a winter view looking south parallel to beach.

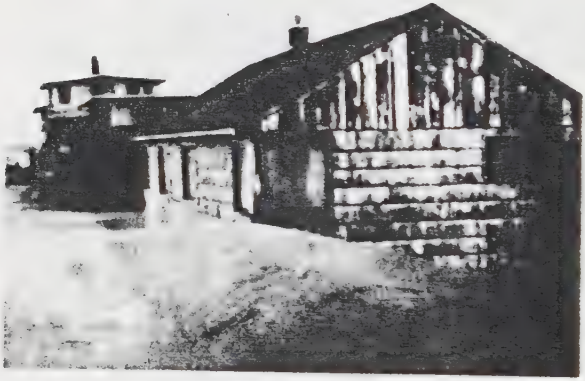

Figure 3 - Active foredune encroaching on building in Seaside, Clatsop County, Oregon.

sand problem was primarily caused by alterations at the mouth of the Columbia River which separates Oregon and Washington. Construction of the south jetty began in 1885 and the north jetty was constructed later. Although the jetties were needed for navigation on the river, which is a major industrial waterway, their construction caused sand to fill in the embayment at the mouth of the Columbia River.

Sand flushed from the river channel accumulated behind the jetties, especially south of the Columbia River. This caused the beach to grow rapidly seaward. At the same time, grazing and fire were destroying the natural vegetation of tall grasses and mature forests on the adjacent dunes. As a result, about 1218 ha (3,000 ac) of exposed active sand dunes had developed by the early 1930's. An aerial view, taken in 1935, shows a wind eroded strip about 2.4 km (1.5 mi) wide extending 20.92 km (13 mi) along the Clatsop Plains coast.

Local residents and the Clatsop County Court requested assistance from SCS. The project, started in 1935, was carried out in cooperation with the Agricultural Experiment Station and the Extension Service. In 1935, the SCS asked the Civilian Conservation Corps (CCC) for help. Camp SCS-7 was established at Warrenton, Oregon to provide the hand labor necessary to stabilize the dunes. CCC enrollees logged and split fire-killed timber, donated by Clatsop County, to build 14.5 km (9 mi) of double-line picket fences parallel to the beach. They also established a spike camp at Coos Bay (Helms 1983) where, under the direction of SCS, they dug European beachgrass culms, which were cleaned, bundeled, and shipped to the Warrenton Project to establish a 2.0 ha (5 ac) nursery (Brown 1938a).

SCS began collecting plant material in November 1935, and by March 1936 had established the 87.1 ha (215 ac) Astoria Nursery Unit to produce beach and dune grass, collect seed, produce shrubs and trees, test plant fertilization, and test cultural methods of dune stabilization (Brown 1935).
The SCS Warrenton Project studies determined that there are three steps in establishing permanent vegetation on the coastal dune areas adjacent to the beach (Brown and Haffenrichter, 1948, Brown and Haffenrichter, 1962, Haffenrichter 1967, and McLaughlin and Brown, 1942). They are:

1. Place sand fencing to establish a foredune immediately above the beach to reduce the movement of sand from the beach inland.
2. Establish grass cover on the foredune.
3. Establish permanent stabilization by herbaceous or woody vegetation which usually follows European beachgrass, if that is the grass used.

The process followed, using these simple steps, is summarized for each procedure as follows:

At the Clatsop Plains, winds average 25.7 km (16 mi) per hour, with winter gales in excess of 88.5 km (55 mi) per hour. In November 1935 prior to these expected high winds, CCC personnel (using SCS guidelines), built two rows of picket fence 9.14 m (30 ft) apart. Starting 15.2 (50 ft) above the high tideline the fence pickets were 4 feet high, 10.2 cm (4 in) wide, placed 10.2 cm (4 in) apart and even across the top. The wind deposited sand along the fence to form a foredune high enough to prevent washover by normal storm tides. Within 8 to 9 months after the fences were established, a dune formed which was 0.46 m (1.5 ft) to 0.92 m (3 ft) high and extended 3.05 m (10 ft) to 4.57 m (15 ft) on both sides of the fences (Schwendiman 1975).

Table 1 Stabilization Programs along the Pacific Coast

Date	Area	Description
1910-1916	Dune area between Florence (Lane County) and Coos Bay (Coos County), Oregon	19.04 ha (47 ac) of trees and shrubs, along with European beachgrass, by US Forest Service.
1926-1928	Spit surrounding the Naval Radio Compass Station across Coos Bay from Empire (Coos County), Oregon	Plantings of European beachgrass and some trees and shrubs including willow, and cluster pine. Bureau of Plant Industry, USDA, cooperating with the U.S. Navy and Commerce Departments.
1934	Suislaw National Forest, 15 miles south of Reedsport (Douglas County), Oregon	31.79 ha (78.5 ac) of European beachgrass were planted as well as 25,000 cluster pines on 26.8 acres, by US Forest Service.
1933 & 1934	Reedsport water supply west of Clear Lake (Douglas County), Oregon	12.15 ha (30 ac) of beachgrass and some trees, by US Forest Service.
1936	Mercer Lake Recreation Camp (Lane County), north of Florence, and other areas between Lake Tahkenitch (Lane County) and Lincoln County, Oregon	16.20 ha (40 ac) of beachgrass; plantings of European beachgrass and shrubs, by US Forest Service.
1935-1949	Warrenton Dune Project at the mouth of the Columbia River to Seaside (Clatsop County), Oregon	Massive, 1215 ha (3,000 plus ac) dune stabilization project using plantings of European beachgrass with secondary plantings of scotchbroom, shore pine and other species, or upland permanent grass seed mixture. Plantings based on large testing program with plants from all over world. Technical assistance provided by SCS with Warrenton SCD providing coordination.
1942-1944	Grayland Copalis Beach, and Westport (Grays Harbor and Pacific Counties, Washington)	About 2.03 ha (5 ac) of European beachgrass planted along active foredunes threatening homes at both locations and 33.62 ha (83 ac)adjacent to beach at Westport. Assisted by Montesano-Elma-Oakville Soil Conservation District, US Army, and SCS.
1948	Mott Island, U. S. Naval Station, Columbia River (Clatsop County), Oregon	4.05 ha (10 ac) of sandy dredge spoils planted with European beachgrass and shorepine. Source of assistance unknown
1952-1970	Bodega Bay Sonoma Coast Park (Sonoma County), California	186.30 ha (460 ac) planted with European beachgrass and other species. Planted by State Parks in cooperation with Gold Ridge Resource Conservation District and SCS.
1949-1955	South Bank of Siuslaw River, Florence (Lane County), Oregon	Several thousand acres of open dune sand were stabilized that threatened the Siuslaw River shipping channel and US 101. Initial stabilization with European beachgrass in upland areas and seed mixture in deflation plain area. Picket fences used in restoration of eroded foredune. Technical assistance provided to Siuslaw SCD by SCS technicians.
1955-1961	Dunes south of Los Berros Creek, San Luis Obispo County, California	Sand fencing and 3.04 ha (7.5 ac) planted with European beachgrass to protect flood control channel PL-566 Watershed Project. Assisted by San Luis Obispo County Flood Control District, Arroyo Grande Soil Conservation District, and SCS
1956	Bayocean Spit, Tillamook Bay (Tillamook County), Oregon	42.93 ha (106 ac), stabilized freshly deposited salt water dredge spoils with European beachgrass plantings. Scotch broom and shore pine added one year later
1958	Bodega Bay (Sonoma County), California	50.61 ha (125 ac) planted with European beachgrass on private ranch Assisted by District and SCS

Table 1. Stabilization Programs along the Pacific Coast, continued

Date	Area	Description
1958 1959	Pismo Beach State Park, San Luis Obispo County, California	4.05 ha (10 ac) around camp headquarters machine planted with European beachgrass acquired from Florence, Oregon, later permanent stabilization with Monterey pine and Monterey cypress. Planted by State Division of Forestry with SCS assistance
1960	North Bank of Coos Bay (Coos County), Oregon Industrial Site	32.40 ha (80 ac), vegetation composed of new salt water dredge spoils and open dune area planted to European beachgrass and seeded grass mixtures.
1961	Vandenburg Air Force Base, Santa Maria (Santa Barbara County), California	20.25 ha (50 ac), machine planting of problem open sand areas in missile launching complex. European beachgrass acquired from Florence, Oregon, was used for initial stabilization of foredune through veldtgrass planted behind foredune for stabilizing several hundred acres. US Army Corps of Engineers assisted by SCS
1963	Salishan Spit, Lincoln City (Lincoln County), Oregon	16.20 ha (40ac), European beachgrass plantings for wind erosion protection. Stabilized for real estate development.
1964 to 1965	Bayshore and Sand Piper Developments near Waldport (Lincoln County), Oregon	102.25 ha (250 ac), European beachgrass plantings used to revegetate and stabilize north spit of Alsea River which was developed to high density real estate.
1966	Umpqua River North Bank at Gradiner (Douglas County, Oregon	32.4 ha (80 ac), vegetative stablization of new salt water dredge spoils with seed mixture to provide for paper mill industrial site.
1967	North Bank, Coos Bay (Coos County), Oregon	40.50 ha (100 ac), European beachgrass and shore pine plantings to vegetate and stabilize open dune sand area. Stabilization in preparation for location of huge ocean wood chip loading facility.
1975 to 1976	Miller Sands (Clatsop County) along the Columbia River	64.80 ha (160 ac), dual purpose research site by Water Experiment Station, U.S. Corps of Engineers. Plant selection and testing of vascular plants for revegetation of intertidal sand dredge spoils. Revegetation for nesting areas on old upland sand dredge spoils.
1976	Neceta Critical Area, Florence (Lane County), Oregon	22.68 ha (56 ac), European beachgrass plantings in upland open dunes to protect airport, golf course, and other natural resources. RC&D project initiated by Siuslaw Soil and Water Conservation District. Assisted by SCS.
1976-1978	Ocean Shores (Grays Harbor County), Washington	27.34 ha (67.5 ac) planted to European beachgrass and associated sand fencing. RC&D project initiated by Grays Harbor Soil Conservation District and City of Ocean Shores.
1980	South Beach Marina, Newport (Lincoln County), Oregon	2.43 ha (6 ac), European beachgrass plantings in new salt water dredge spoils for wind erosion and ornamental reasons. RC&D project initiated by Lincoln County, Soil & Water Conservation District, and Port of Newport. Assisted by SCS.
1980	Twin Harbors State Park (Pacific County), Washington	3.65 ha (9 ac) planted to European beachgrass. RC&D project initiated by Grays Harbor Soil Conservation District. Assisted by SCS.
1982	Morro Bay (San Luis Obispo County), California	8.50 ha (21 ac) machine planted with European beachgrass acquired from Florence, Oregon by City of Morro Bay to protect park and streets Assisted by Resource Conservation District and SCS.

In late winter and early spring of 1937-1938, European beachgrass was planted and fertilized on the newly developed dune between the pickets, as well as 15.24 m (50 ft) toward the ocean on the windward side of the fence, and 30.48 m (100ft) to the leeward side of the back fence (McLaughlin 1938). By January 1938 a strip of grass 15.24 m (50 ft) wide (30.48 m wide in some places) had been planted from the Columbia River to Gearhart, Oregon, a distance of 20.92 km (13 mi)(Steele 1937).

Permanent stabilization by herbaceous or woody vegetation followed the European beachgrass by one or two years. When sand has been partially to completely stabilized, the initial grasses such as European beachgrass, American beachgrass (Ammophila breviligulata Fernald), and, to a lesser extent, American dunegrass (Elymus arenarius susp. mollis (Trin.) Hulten), lose their vigor. Some plants die leaving open spaces where blowouts can occur. Nitrogen can be applied annually or biannually, but a better practice is to seed permanent species, especially legumes, which can supply the necessary nitrogen.

Seaside lupine (Lupinus littoralis Doug.), which is native to the Oregon-Washington dunes, was one of the successful legumes used in secondary dune stabilization, particularly in the early years of the Warrenton Project. It germinates readily, has strong seedling vigor, and it usually sets a crop of seed the first year. It is a perennial which forms an almost complete cover, dies down in the winter, leaves a persistent mulch, and provides nitrogen, paving the way for perennial grasses. Seeds ripen unevenly and pods shatter readily, so seeds must be collected by hand (Schwendiman 1975). Purple beachpea (Lathyrus japonicus Willd.) was another important native legume. Frequently used, it could be locally collected. Lupine withstands vegetative competition but, as the grass sod becomes compact, it is generally supplanted by native clovers (Schwendiman 1975).

SCS tested 75 species of native, naturalized, and exotic shrubs at the Astoria nursery. The species considered most suitable as intermediate stabilizers on Pacific Northwest dunes were not the native seaside lupine or purple beachpea, but three others. These were scotch broom (Cytisus scoparius (L.) Link), tree lupine (Lupinus arboreus Sims), and coyotebrush (Baccharis pilularis DC.)(Brown and Haffenrichter 1962). SCS tested 80 species of trees for use in permanent stabilization. Shore pine (Pinus contorta Dougl. ex Laud.) was found to be ideally suited for semipermanent stabilization until shaded out by climax species. Permanent stabilizers, such as Sitka spruce (Picea sitchensis (Bong.) Carr.) and western hemlock (Tsuga heterophylla (Raf.) Sarg.), slowly volunteer into stands of trees planted for semipermanent stabilization (Brown and Haffenrichter 1962).

A comparison over time of dune areas in the Warrenton Project is shown in Figs. 4, 5, 6, and 7.

The SCS and CCC completed most of the initial control work on the Warrenton Dunes Project by 1941. In the spring of 1941 the dune area landowners organized a soil conservation district under the laws of the State of Oregon. The Warrenton Dune Soil Conservation District has administered the dune stabilization work since that time with technical assistance from SCS and other agencies. To further insure permanent control of the shifting sands, in April

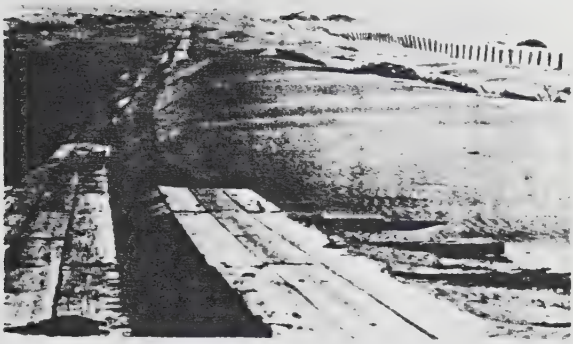

Figure 4 - Drifting sand in August 1935 crossing wood plank road to historic 1906 Peter Iredale Shipwreck, Fort Stevens State Park, Clatsop County, Oregon. Shipwreck shown at sloping pole to right of road and sand fence.

Figure 5 - August 1936 view of wood plank road to Peter Iredale wreck, shown in Figure 4. The first year's growth of European beachgrass is apparent.

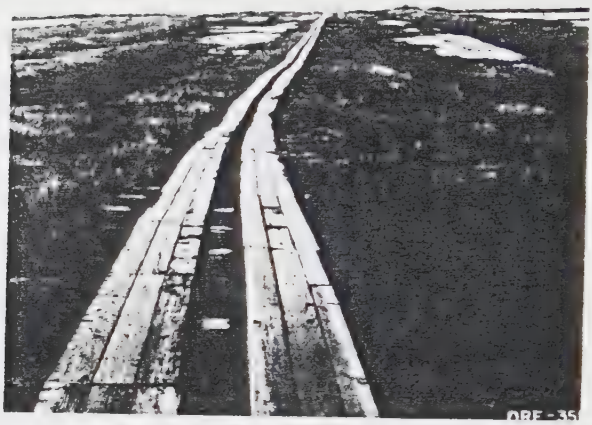

Figure 6 - August 1937 view of wood plank road to Peter Iredale wreck shown in Figure 4. Established European beachgrass and Scotch-broom in foreground. Wet areas along plank road apparent in center background. New formed foredune in background in front of Peter Iredale.

Figure 7 - September 1961 view of road to Peter Iredale shown in Figure 4 (26-year time span). Paved road has replaced wood plank road. Semi-permanent stabilization by shore pine and Scotch-broom apparent in foreground. A 35-foot foredune hides Peter Iredale shipwreck.

1948, this district adopted land use ordinances setting forth proper use of the land (Leach 1964). The ordinances divide the Clatsop Plains into two zones: zone 1 is high hazard and zone 2 is lower hazard.

The Warrenton Project established the dune stabilization procedures which would be used on the West Coast for the next 50 years. A variety of plant materials were tested and used, but European beachgrass was determined to be the principle pioneer species for establishing grass cover on sand dunes from the Straits of Juan de Fuca at the Canadian border, south, to Los Angeles, California.

The Siuslaw Soil Conservation District supervisors, USDI, Bureau of Land Management, USDA, Forest Service, and USDA, Soil Conservation Service, cooperatively planned control of about 1417 ha (3,500 ac) of moving sand within the Siuslaw District in Lane County, Oregon. Planting was started in the winter of 1949-50, with several thousand hectares stabilized by 1955 (USDA, SCS, Carlson et all, in press).

To produce beachgrass, furnish technical advice, and assist in training planting crews, SCS established (from the Bellingham Nursery) an outlying nursery south of Florence in 1949. The Florence nursery furnished over six million beachgrass culms in 1949-50. It supplied two-and-one-half million culms to the Siuslaw District, and two million to the Army Corps of Engineers for a special control job. One-and-one-half million culms were used by the nursery to establish more production areas (USDA, SCS, 1949). Even greater amounts were produced and distributed in succeeding years including large quantities of scotch broom and shore pine.

In contrast to the foredunes and parallel ridge dunes planted in the Clatsop Plains, the Siuslaw plantings were primarily on the high open dunes of the oblique or parabolic type (Cooper 1958 and Reckendorf 1975). These could be shaped prior to planting, machine planted, and refertilized periodically to rejuvenate weak spots (Ternyik 1979). The main nursery area was also on these high dunes south of Cleawox Lake in Lane County. SCS closed the outlying nursery near Florence as part of a reorganization of plant material functions in 1954. The Siuslaw District continued to operate the nursery in cooperation with a private nursery.

WASHINGTON

Camp enrollees from CCC camp, SCS-w-12 assisted SCS and the Montesano-Elma-Oakville Soil Conservation District with a variety of conservation work including sand dune stabilization work at Copalis Beach, Westport, and Grayland in Grays Harbor County (Springer 1984). In February 1942 the CCC enrollees, with SCS technical assistance and the U.S. Army support, stabilized 33.62 ha (83 ac) of blowing sand adjacent to the beach at Westport, Washington. They planted European beachgrass obtained from the Astoria Nursery Unit to stabilize the foredune. The Astoria Nursery also provided scotch broom, snowberry (Symphoricarpos Spp.), and black locust (Robinia pseudoacacia L.), so that permanent cover could be established in the backdune area. The foredune plantings were needed for both stabilization and camouflage (USDA, SCS, 1942).

Very little additional dunes stabilization occurred on the Washington Coast until the late 1970's. In the winter of 1974-75, the north Grays Harbor jetty was washed out by a major storm which also destroyed a portion of the adjacent foredune. Wind erosion became active on the remaining dunes. In addition, there was active dune movement in the nearby city of Ocean Shores. These dunes were covering roads, lawns, and drifting around homes. The SCS, in cooperation with the Grays Harbor Soil Conservation District, installed sand fencing and planted 27.34 ha (67.5 ac) of European beachgrass as a project action under the Columbia-Pacific Resource Conservation and Development (RC&D) Project. This RC&D also supported a project in 1980 at Twin Harbors State Park south of Westport. In the later project, 3.65 ha (9 ac) of European beachgrass were planted on a parallel ridge dune to reduce sand blowing in the state park and to protect a church property and a state highway.

CALIFORNIA

Early in the 20th century, residents of Bodega Bay in Sonoma County, California, learned that a grass introduced from Holland, European beachgrass, was being used to control blowing sand at the Golden Gate Park in San Francisco. With culms acquired from Golden Gate Park, trial plantings were made at Bodega Bay. The plantings grew well, and provided a source of material for additional plantings. Grass was planted along the western perimeter of the Bay. Each winter for about 20 years, local residents with a team of horses, a plow, and culms of beach grass, extended the treated area. Then for some reason, with 405 ha (1,000 ac.) of active dune remaining to be planted, control work ceased (USDA, SCS 1967).

Later in the 1950's stabilization started again at Bodega Bay. Historically, forests have not developed on the parabolic high dunes in this area. Instead, a desert shrub plant community provides long-term stabilization and the range of the desert shrubs extends south to the Mexican border (Cooper 1967). In 1952 stabilization started in the Sonoma Coast State Park with European beachgrass. By 1970, 186.3 ha (460 ac) in the park had been stabilized by a combination of European beachgrass, tree lupine, perennial veldtgrass (Ehrharta calycina Thumb.), seaside brome (Bromus carinatus maritimus (Piper) C. Hitch.), ice plant (Carpobrotus aequilateralis (Haw.) N.E.Br.), myoparum (Myoparum lactum G. Forst), and Monterey cypress (Cupressus macrocarpa Hartw.) (Campbell 1984). In 1958 European beachgrass was planted on 50.63 ha (125 ac) of adjacent private land. Over the years, the Gold Ridge Resource Conservation District supported the dunes stabilization efforts and obtained financing from the State of California for fertilizations to maintain the stands of beachgrass. Other plants have been used as stabilizers but have had varying success (Moore 1984). Mice, rabbits, and deer have keep most of the forage plants grazed.

One of the early SCS PL-566 watershed projects, Arroyo Grande Creek Watershed, San Luis Obispo County, California, had a wind erosion problem from high dunes along 1.7 km of the Los Berros flood control channel. The November 22, 1955 watershed work plan proposed sand fences and planting of 3.03 ha (7.5 ac) of beachgrass (USDA, SCS 1955). By 1957, the sand fencing was installed, along with 2.84 ha (7 ac) of hand planted European beachgrass acquired from Golden Gate Park in San Francisco (Barnes 1984). In 1969 the San Luis Obispo County

Flood Control and Water Conservation District machine planted an additional 8.1 ha (20 ac) with European beachgrass acquired from Florence, Oregon to protect the Los Berros channel and the adjacent prime agricultural land (Moore 1984).

In 1961, SCS assisted the U.S. Army Corps of Engineers in stabilizing dunes to protect the missile launching area on Vandenburg Air Force Base, north of the Santa Maria River in California. The beachgrass was planted after the sand fences were placed 9.14 m (30 ft) apart, in a similar way to those on the Warrenton Project in Oregon. Sand built up along the fences to form two parallel foredunes which reached heights of 9.14 m (30 ft). European beachgrass was planted on 15.24 m (50 ac) of foredune. The foredunes protected the area inland from direct sand transport from the beach. Veldtgrass was planted to stabilize the windblown sand on several hundred more acres behind the foredunes (Moore 1984).

In 1982, in nearby Morro Bay, SCS assisted the City Park Department in plant ing 85.5 ha (21 ac) of European beachgrass in Morro Bay State Park. This planting protected park property and a PGE steam generated electric plant. This area has high recreational use, and planting is 90 percent successful despite heavy foot traffic. Park officials plan to add a variety of native plants now that the blowing sand is nearly stabilized (Moore 1984).

In summary, the early success of the large scale Warrenton Dunes Demonstration Project, in Oregon, provided both technical information and an incentive to the stabilization projects that followed throughout many other areas of the West Coast. Twenty five other stabilization projects were identified in Oregon, Washington, and California. All the projects were based on site investigations and analysis of the physical limitations of the sand dunes resource. The analysis identified ways to stabilized blowing sand dunes and hazards of construction in dune areas.

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United States
Department of
Agriculture

Soil
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Agriculture
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Stabilizing Coastal Sand Dunes in the Pacific Northwest

Cover: European beachgrass is the dominant plant for stabilizing frontal dunes in the Pacific Northwest.

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August 1991

Stabilizing Coastal Sand Dunes in the Pacific Northwest

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Introduction

Extent and Location of Dunes

The Pacific Northwest Coast is defined as the area from Cape Mendocino, California, to the Strait of Juan de Fuca, Washington. This area has a similar climate, vegetation, soil, and geology, as well as similar variation in wind and wave action.

Many types of sand dunes and sand spits, which make up 250,000 acres of the Pacific Northwest coast, provide exceptional recreational opportunities as well as rich habitat areas for wildlife. Of the total dune area, about 26,000 acres are dunes with essentially no vegetation; and of these, nearly 5,000 acres are "active" dunes that threaten competing land uses. Active dunes, so called because they lack a stabilizing plant cover and are subject to extensive movement by wind action, advance onto forests, lakes, stream channels, roads, railroads, estuaries, and agricultural land. Every year several hundred acres of vegetated dune land are disturbed, mainly as a result of human activity, and become new active dunes.

Landowners and community planners face the challenge of selecting a dune stabilization plan that protects adjoining property and natural resources yet preserves sufficient open, active dune land for public recreation, aesthetics, and scientific purposes. To assist them, this publication draws upon the more than 50 years of infield dune management experience of the U.S. Department of Agriculture's Soil Conservation Service (SCS). It reviews fundamental dune-building processes, describes how to plan a dune-control program, and explains the mechanical aids, plants, and planting techniques for dune stabilization.

The recommendations in this publication apply specifically to the dune lands in the Pacific Northwest. Some of the plants, however, have been grown successfully as far north as Vancouver Island, Canada, and as far south as Morrow Bay, California. (See appendix I for common and scientific plant names used in this publication.)

Typical dune development in early stages of natural revegetation.

Residential and resort development are common on stabilized dunes, but vegetative cover must be maintained and managed to minimize sand deposition and damage to buildings. Building in beachgrass vegetation on or near foredunes is considerably more risky than further inland on much older stabilized dunes.

Formation of Dunes

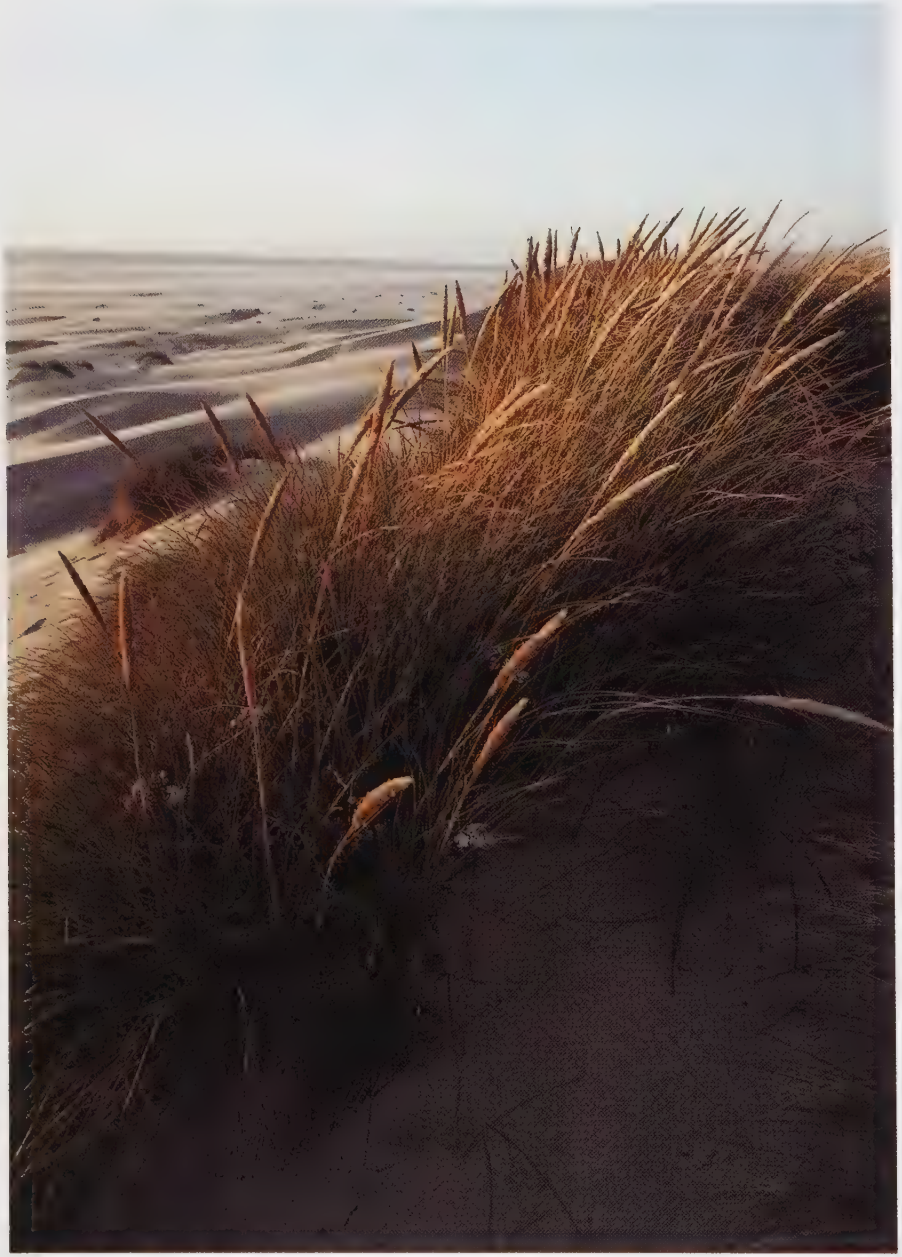
Coastal dune formation is determined by four factors: wind action, wave action, vegetation, and source of sand. The two immediate sources of dune sand particles are the erosion of coastal formations exposed to wave attack, and sediment load from rivers. Ocean currents move sand from eroding headlands, and from the mouths of rivers, to where there are indentations in the coastline. As sand is deposited on beaches, it is exposed at low tide, dries quickly, is caught by the wind, and is carried inland. Along the Pacific coast there is almost always a moderate wind. At times the wind approaches hurricane force. High-velocity winds move enormous amounts of sand inland.

After a winter storm, rivers and streams carry a heavy load of sediments from the upper watershed. This sand is combined with that derived from storm waves attacking sea cliffs, dunes, and spits. These storms provide a seasonal near-shore sand supply, whereas lower-energy waves and currents, which occur more on a continual basis, transport the near-shore sand to beaches and tidal inlets (Peterson et al., 1982).

Waves reaching the coast generate longshore currents in the near-shore area that are important in the movement of sand along the beach and in beach erosion. When waves break at an angle to the shoreline, they generate a current that flows parallel to the shoreline (Komer 1976). This current, together with the waves, produces a transport of sand along the beach known as littoral drift (Komer 1979). Winds and associated waves arrive from the southwest during winter months and from the northwest during the summer months. As a result, littoral drift changes direction from season to season.

Recent work (Chesser and Peterson 1987) based on physiographic and mineralogic analysis indicates that there are at least 17 major littoral cells along the Pacific Northwest coast. Their preliminary results indicate longshore transport is bounded by major headlands and is highly correlated to the prevailing wave approach angle. They also concluded that episodic events may overshadow seasonal cycles of transport.

Dunes form and reform naturally or from human activities. Concentrated wind channels frequently create blowouts, or areas where wind removes existing vegetation.



Sand deposited on the beach is blown inland and trapped by European beachgrass, creating a frontal foredune. Without the introduced beachgrass, the native landscape typically would be more open and hummocky. The foredune has enabled greater development and use of the coastal zone.

The three largest littoral cells are associated with the three largest rivers—the Columbia, the Umpqua, and the Eel (Chesser and Peterson 1987). Therefore, it is no surprise that some of the largest dune areas occur in areas near these major rivers. Jetty construction on the Pacific Northwest coast also has a major effect on littoral sand drift and accumulation. Sand accumulates on both the north and south sides of jetties from the seasonally reversing waves. Embankments, formerly at the mouth of rivers, are filled with sand. This sand accumulation can be quite fast, such as behind the south jetty of the Columbia River. Between 1885 and the 1930's, a prograding beach developed in this area, resulting in 3,000 acres of open, active sand dunes.

Vegetation is a major factor affecting dune formation. Along a barren shore, dunes are oriented transversely or obliquely to the wind, depending on the existing wind regime. Prior to 1900, native coastal dune plants altered a barren dune area by generally making it hummocky in appearance. However, since then, introduced European beachgrass has been the primary pioneer species on newly deposited sand.

Plants establish and advance along the beach to the normal tide line, where they are halted by tide action. The stiff, coarse stems decrease the velocity of the surface wind and trap the sand. Thus, instead of a hummocky landscape or a series of transverse and oblique ridges of barren sand, a grassy foredune develops parallel to the coastline (Cooper 1958). The greatest amount of sand movement along the North Pacific coast takes place during the high-velocity winter wind storms. At this time sand engulfs the foredune vegetation. During the spring and summer, however, vegetation grows up through the sand and forms a lush growth. This is covered again the next winter, and a continuous sand ridge, built layer by layer, extending without interruption, and parallel to the coastline, results. The lands lying to the leeward of the foredune are protected from the scouring action of the sand-laden wind and a dense sod or forest cover eventually develops.

If sand is deposited more rapidly than it is blown inland, the beach line will build oceanward. The vegetation will advance to a new storm tideline, and a new foredune will be formed oceanward from the old foredune. Incoming sand will be deposited on the new foredune, and the old foredune will become vegetated by plants better suited to stable conditions.

This typical dune-building and dune-stabilizing process can easily be disrupted, however, by disturbance of the vegetal cover. When vegetation thins and sand is exposed, the wind lifts and carries it

until vegetation or some artificial barrier causes it to deposit. Scouring often results in a blowout, a widening gap of open sand that can move a considerable distance inland. From such occurrences, a large active dune area may develop. Anything that destroys the vegetal cover furthers the development of active dunes. Active dunes may move for long distances over a flat plain before they are finally dissipated or stabilized.

Human activity has a profound effect on coastal dune areas, directly or indirectly accelerating or renewing dune activity. Fire can cause large active dune areas to form, both on the coast and inland. Destruction of recently stabilized dunes by fire exposes sand directly to the wind.

Further inland, fire can destroy the humus that has accumulated from hundreds of years of plant growth. This humus is the layer of decaying organic material that overlies the gray dune sand. The accumulation of organic matter on stabilized dunes over time enables further plant succession and an environment conducive to a greater variety of land uses. Fire can destabilize a dune management area quickly, and prevention is a primary concern.

In the past, overgrazing by livestock has been a significant cause of active dunes. Repeated trailing by livestock cuts through vegetation and the thin topsoil to the sand below, causing blowouts.

As stated previously, jetties, such as the ones built at the mouth of the Columbia River, have contributed to active dune formation. The south jetty built at the mouth of the Columbia River extends 7 miles to the sea, and the north jetty extends 3 miles. Construction of the jetties has scoured the main river channel, and much of the scoured sand has been deposited north and south of the mouth of the river. A low-lying sand flat south of the river has built oceanward, with its maximum width near the jetty. It extends several miles southward and gradually narrows until it meets the old beach line.

Ordinarily, a beach builds oceanward so gradually that vegetation keeps pace. Thus, the sand is stabilized as rapidly as it is deposited. In the case of the wide plain to the south of the Columbia River jetty, the beach line built oceanward too rapidly for the vegetation to keep pace. Occasional clumps of sand-stilling grasses washed onto the flat, took root, caught sand, and built up scattered hummocks. Generally, however, there was little vegetal cover to hold the sand. The prevailing winds moved the sand inward to form an extensive area of active sand movement. Similar problems have occurred in all cases where jetties have been built at the mouth of rivers on the North Pacific coast.

Construction of jetties usually results in the movement of the beach seaward. Note the advance of a new foredune from the old one at the mouth of the Siuslaw River near Florence, Oregon.

Recreational vehicles have become a major cause of active dunes in recent years. Motorcycle and other dune traffic easily destroy beachgrass and associated vegetation. Blowouts sprout quickly, and a large dune area can become active again.

Other causes of active dune processes include road construction, wearing of trails, regrading for building sites, and cultivation. In general, any destruction of the vegetal cover in an area of sandy soil is likely to start sand movement. The unprotected site starts as a blowout, which increases in size. Controlling an unwanted large blowout can be very expensive.

The Need for Selective Stabilization of Dunes

Dune stabilization is needed to:

1. Protect other natural features, such as lakes, wetlands, forests, and estuarine habitats along coastlines;
2. Protect improvements, such as highways, parks, shipping channels, and urban development;
3. Create sheltered wetland habitat or upland habitat for wildlife;
4. Provide needed beach access for recreational use; and
5. Overcome hazardous situations.

Yet, there also is considerable public demand for unstabilized, active, open dunes. This became apparent with the public comments on plans for the Oregon Dunes National Recreation Area and Oregon's Coastal Zone Management plans during the seventies. The public voiced their desire for open dune areas left in their natural state for recreational and scientific purposes. Plans, therefore, provide for hiking, dune buggies, photography, and camping areas such as Umpqua Scenic Area south of Winchester Bay and other dunelands left in their natural state. Underscoring the preference for open dunes, more than 40 percent of all visits to the Oregon Dunes National Recreational Area are to open sand areas.

Movement of large sand dunes affects human activity in coastal zones. Here a community must weigh the costs of maintaining a navigational channel and the benefits derived from preserving open dune areas.

Large parabolic dunes can move several hundred feet per year, invading spruce forests and encroaching upon highways, freshwater lakes, commercial developments, and other planned land uses.

Here a city water supply tower foundation must be protected from scour and undercutting.

Planning a Dune Control Program

The necessary balance between open, uncontrolled dune movement and selective stabilization is only achieved through sound planning and management, and usually requires considerable infield dune management experience. Such experience acquired over 50 years along the Pacific Northwest coast has caused a gradual shift from planting 99 percent of a problem area to smaller plantings that afford adequate protection of significant resources. A summary of the type of sand dune stabilization work that has been done on the West coast during the past 50 years is presented in Reckendorf et al. (1985, 1987).

Land Use

Recreation is the main land use that allows appreciable areas of active dunes. Size of the recreation area determines how much should be stabilized and how much should be left open. Active dunes left open should be slow moving, have room to move, and have a sand supply that can be controlled. Buffer strips of tall trees are useful for slowing the advance of dunes. Dune movement must also be predictable, and this depends on a thorough knowledge of dune history in the area, dune formation mechanics, and wind conditions. As active dunes encroach on incompatible land uses, they must be stabilized and new active dunes opened up elsewhere on the recreation area. The alternatives are to remove sand from the adjacent land or to sacrifice the adjacent land use to recreational purposes.

Very large, open active dune areas that have existed naturally since before the coast was settled have high potential for recreation and scientific study. They are made compatible with adjacent land uses by the use of adequate buffer zones to slow the movement of sand inland.

Urban Land. Residential and industrial development cannot coexist with open dunes unless land users are willing to pay for sand removal and tolerate sand deposition and abrasion. Houses often are constructed on sand spits; on, into, and behind foredunes; and on older stabilized dunes. In all cases, the surrounding area should at least be stabilized with beachgrass. Sand deposition on floors and sills is still a problem in areas stabilized with beachgrass, but less where older woody vegetation has become established. Clearing wooded areas for construction on dune sand can interrupt moisture availability and inadvertently kill adjacent trees. Urban development on stabilized dunes is much riskier than further inland.

Beachgrass is planted on the far dune to slow its encroachment inland towards a lake and other developments.

Community Services. Utility rights-of-way, highways, airports, ship channels, and other similar uses do not tolerate great accumulation of sand. Highway cuts and fills, as well as rights-of-way, almost always have to be stabilized. Waterways must be well buffered by vegetation on both banks to prevent clogging.

Woodland. Commercial or private woodlots are only possible in well-stabilized areas, well away from sand deposition and protected from wind blast, which shapes coastal trees into odd picturesque forms. Soil moisture balances are fragile on dune sand and can be upset by improper timber management. Loss of soil moisture can result in blowouts.

Wildlife Habitat. This land use can be primary or secondary. It also is the most compatible with recreation use, if the area is large enough to permit adequately diverse vegetation and fresh water. A mixture of forest, shrublands, grassy areas, and open dunes in combination with marsh habitat on deflation plains is the most desirable habitat for coastal wildlife. Recreation use can sharply reduce various animal populations, particularly with off-road vehicle traffic and high-density camping or day use, but tradeoffs are made either way, depending on which use has priority.

Cropland and pasture usually are not recommended uses for dune areas. These uses are limited to areas where the water table is high.

This strategically placed beachgrass planting in an open dune area will help to control sand movement into a lake that has high recreational value.

Cranberries are the most commonly cultivated crop. Cultivation on dune sand requires wind protection and is feasible only on a small scale. Pastures must be properly grazed to ensure that humus layers are not destroyed. Agriculture is impossible on open active dunes.

If an undeveloped site has active dunes, the owner or operator may stabilize it to permit residential or commercial use. The operator also may work with adjacent landowners to control dunes, or land use ordinances may require that certain areas be permanently stabilized to permit land uses that are not compatible with active dunes. Where complete stabilization is necessary, a dune treatment plan is relatively simple and follows the procedure outlined later in this publication. If active dunes are planned for recreation or natural areas, the land manager must consider controlling the sand supply, the area to be occupied by the dune, the direction of dune movement, buffer vegetation, eventual stabilization of the dune, and alternate dune sites. Vegetation is used to control open sand supply and build buffer strips. Adjacent areas that are not to remain active are stabilized with vegetation.

Dune Management Areas

Ternyik (1979b) recommends dividing dune land into dune management areas. Delineation of these areas follows significant natural or artificial boundaries that prevent dune movement. The boundaries may include lakes, rivers, channels, concentrated urban developments, and highways. By comprehensively considering an entire dune management area, local planners can recommend suitable land uses. Management areas can include several land uses, and it is important to ensure that all are compatible. Also within dune management areas are three dune landforms (Crook 1979) which must be considered to integrate elements of a dune control plan.

The type of dune landform determines how a dune is stabilized with vegetation:

1. **Foredune Area.** The barrier ridge of sand immediately above the high tide line and paralleling the beach is the foredune (Reckendorf 1975 and Crook 1979). It can be divided into the frontal section facing the ocean, the top surface, and the lee side (side protected from the wind). If no foredune is present, the area from the high tide line back 200 feet is considered the foredune area. This area is the one most affected by direct ocean sand supply.

Foredunes are subject to wave attack, severe winds, and constant sand movement and, therefore, are stabilized primarily with pioneer dunegrasses. The front and top of the foredune are vegetated to dunegrasses exclusively, whereas the more protected lee side can be planted to secondary grasses, legumes, and woody plants in addition to dunegrasses.

Beach sand movement and wave attack keep frontal areas in a constant pioneering stage. Vegetation on the foredune will prevent sand movement inland but will not stop erosion caused by wave attack. Therefore, if a beach over the long term is degrading, the foredune eventually may be destroyed by wave erosion. Severe storms or an abrupt cutoff of beach sand supply may also result in the destruction of a foredune by wave action.

Natural foredunes are created by sand-stilling dunegrasses. Blowouts in foredunes occur when the grass cover is disturbed, opening a wind tunnel for further sand movement inland. Foredunes can be created mechanically using sand fences and then vegetated.

High planting densities are required for dunegrasses on the front and top of foredunes. High fertilizer rates also are necessary for plants to establish rapidly and withstand the severe conditions. Plantings require periodic refertilization for at least 2 years to maintain a vigorous cover.

Recreational use continues to increase.

Afterwards, stands usually thrive on nutrients provided by the continuous supply of windblown sand. The lee side of the foredune is less intensively planted to dunegrasses. Secondary legume seedings or woody plantings provide fire protection between the high-fuel-volume dunegrasses and inland areas.

Parallel ridge dunes are vegetated foredunes that have been supplanted by new foredunes to the ocean side. These ridges and other stabilized areas are surface-stabilized dunes that have a weakly developed topsoil layer. The degree of soil development depends on how long the dune has been stable. Recently stabilized dunes are more fragile than those with a mature forest canopy. All surface-stabilized dunes can be destabilized if vegetation is destroyed and the dune mantle subjected to wind. Some residential developments have encountered problems during lot clearing when duff and humus layers are removed, killing large areas of tall trees that rely heavily on these layers for moisture and nutrients. If developments occur close to wind corridors, blowouts can occur even in wooded areas.

2. **Interdune areas.** Adjacent to the foredune's lee side are flat areas called deflation plains (Reckendorf 1975 and Crook 1979). These interdune areas are scoured down to the water table and are seasonally wet. Deflation plains usually support marsh plants and are valuable habitat for waterfowl. Most sites are seasonally wet and can be planted to cereals for waterfowl or to wet-tolerant pasture species for big game. In a few cases, especially where sand or dredge spoils are deposited, marsh creation may be required in the reclamation plan.

Interdune areas also may be hummocky, with islands of sand partially stabilized by dunegrasses. These areas are not easily vegetated without shaping and grading to eliminate the hummocks or to make them fit the contour of the land. Hummocky interdune areas have high recreational value and so revegetation may be undesirable. If necessary, leveled hummocks are stabilized to dunegrasses.

Deflation plains can be rapidly invaded by woody plants, particularly Hooker willow, which some land users may not want. Pasture grasses and legumes drill-seeded on the deflation plain can retard willow invasion.

3. **Interior Dune Areas.** This zone is the farthest inland, usually adjacent to headlands, and contains several types of dunes (Crook 1979). These dunes may be unvegetated or vegetated older dunes. Interior dune areas are not subject to appreciable ocean sand supply. They may be active dunes of low transverse ridges or massive oblique ridges, which are characteristic in open unvegetated areas; or they may be blowouts in vegetated areas, which can result sometimes in a giant trough ending in a large accumulation of sand on a previously vegetated area. These giant troughs are called parabola dunes and often are fed by oblique ridge dunes.

Interior dunes are stabilized initially to dunegrasses, similar to treatment of foredunes. Large open dune areas are easier to stabilize than small blowouts on stabilized dunes, because large open areas can be more easily shaped without damaging adjacent vegetation.

Secondary plantings into established dunegrasses provide more permanent control. Plantings may be herbaceous grasses and legumes, woody shrubs, trees, or combinations. These plantings should emphasize fire retardance, wildlife habitat, and improved stabilization. Because inner dunes do not receive salt spray, certain landscape ornamentals can be grown if cared for properly.

Wildlife habitat plantings should be a mixture of forest, shrubland, and open grassy areas. Some open sand may even be desirable. Older stabilized dunes with a weakly developed soil profile are fragile environments even if covered by tall trees and thick underbrush. Disturbance of the plant cover and thin topsoil can be catastrophic because most roots usually are concentrated near the top duff layer to capture moisture and nutrients that have accumulated.

Dunes that have been stable for hundreds or thousands of years have a deep, well-developed soil profile and are not classified as dune sand in soil survey reports. These soils are also underlain with moderately cemented sand. Blowouts are rare on these soils, but deep road cuts and excavations expose the underlying uncemented sands to blowing.

An example of damage to an older stabilized dune area occurred on a golf course in Oregon. The course contained stabilized dunes that separated the fairways. These dunes had a dense cover of salal, huckleberry, and 40-foot shore pine. Because players often lost golf balls in the dense cover, the owner removed all the brushy species and left the beautiful stand of pine trees. However, all the pine trees died during the first summer because removing the ground cover increased the loss of water through evaporation.

Rather than leave the ground bare, the owner could have used bark mulch to cover the area. Placement of bark mulch 3 or 4 inches thick can prevent massive water loss. In all cases, changes to older, stabilized areas should be carefully planned and thought out before they are undertaken.

Before disturbing a site, the stabilization team may examine root profiles to determine where roots are distributed in the soil or sand and to identify trouble spots to be avoided when grading. Root profiles are core samples taken on a grid superimposed over the site. Actual disturbance must be kept to a minimum and the area disturbed should be mulched heavily with 3 to 4 inches of bark dust immediately after disturbance.

Also most important is the effect of depth of disturbance on the existing vegetation. A deep cut on sloping land may drain the water table and source of moisture for shrubs and trees upslope. Woody plants usually have an extensive feeder root system in the top foot of the soil. However, large roots also penetrate deep into the sand to the top of the ground water table; therefore, plants survive seasonal dry periods. Disturbing the top surface layer or lowering the water table can be the two activities having the most destabilizing effect on older vegetated dunes.

Care must be taken to avoid creating wind tunnels during construction or other activity on tree-covered dunes. Tunnels could result in serious blowouts, which can be difficult and expensive to repair. Dunegrass can stabilize blowouts. However,

establishing dunegrass may be difficult along the edges where competition and shading from the adjacent woody vegetation may be the most extensive.

The dune management area concept has been used successfully by the U.S. Army Corps of Engineers (1974) to manage dredge spoil disposal and stabilization along Oregon's coast. The Warrenton Soil and Water Conservation District, formed to control dune formation and movement on the Clatsop Plains, uses this concept also. The district delineated two zones and tailored ordinance restrictions to each (Reckendorf 1975 and Reckendorf et al. 1985). More than 3,000 acres were stabilized in a large-scale effort during the thirties and forties. It has been the most successful dune management program to date on the Pacific coast and one of the most successful in the world.

Site Investigation

Site investigation reports, proposed by Ternyik (1979a), help the planner and the landowner answer key questions about dune management: How does stabilizing this site fit into the planning objectives of the dune management area? What effect will the work have on adjacent land? What are the physical and biological

Agricultural use of interior, older stabilized dunes is decreasing.

conditions in the area? Is maintenance feasible and practical?

Appendix II is a checklist adapted for site investigation on the Oregon coast (Nelson 1976). Help in site investigation is available from local soil and water conservation districts, other local agencies, and consultants.

An effective stabilization plan mimics and accelerates the natural process of plant establishment on sand dunes. Planting sand-stilling grasses imitates the natural invasion of pioneer species on the dune. One of three naturally occurring dunegrasses is used as the pioneer.

As the dune is stabilized by the initial plantings, other grasses, herbs, and legumes can be introduced to increase the content of organic matter in the top sand layer. More permanent woody plants are established in the humus of the stabilized dune and can volunteer from surrounding forest areas as the natural process of succession takes over.

Maintenance

As important as forethought in planning a stabilization project is maintenance of the plant cover. Maintenance involves more than completing all phases of establishment of a new planting. Also essential are human and vehicular traffic control, adequate fire control measures, and revegetating disturbed or thinned-out areas even in old, well-established plantings.

The best way to spot trouble is to check the project systematically three or four times a year and after each major occurrence of high wind. Maintaining a sand dune takes commitment to realize a return on the investment.

The six steps required to stabilize an active dune permanently are:

1. **Prepare the site.** This step may entail the use of temporary mulches, blankets, and sand-trapping fences; grading the site to conform it to the landscape; and minimizing the effects of wind on the proposed planting.

2. **Plant sand-stilling dunegrasses.** This is by far the most dramatic, visible step.

3. **Maintain dunegrass stands.** Replanting and fertilizing are the primary tools for maintaining an even vegetal cover. Temporary mechanical aids may be useful.

4. **Plant secondary grasses, legumes, shrubs, or trees.** Usually done 2 years after planting, this step greatly accelerates the stabilization of the dune. If secondary plantings are not made, dunegrass must be fertilized continually to maintain adequate stands and dune cover until succession introduces secondary species.

5. **Maintain secondary plantings.** Low-vigor spots mean that any vegetation, including dunegrass, will not protect the site for long. They must be fertilized and, if a small blowout has occurred, must be replanted as well.

6. **Incorporate landscape plantings.** Ornamental or general landscape plantings for homesites, parks, roadways, and other uses are common on stabilized dunes. Such plantings are expensive and may require expensive maintenance, particularly irrigation, mulching, pruning, fertilizing, mowing, fencing, and weed control. These plantings usually are incidental to dune control but eventually are made for the most prevalent land uses on stabilized dune land. Such plantings must take into account the unique nutrient, wind, moisture, and salinity conditions on stabilized dunes, as well as the consequences of leaving any area devoid of vegetation.

Fenced walkways often are useful in planted areas that are highly susceptible to scour and blowouts. They can also reduce maintenance costs.

Sand-Stilling Dunegrasses for Initial Stabilization

Species

Beach or dunegrasses are the most widely useful sand-stilling plants for initial plantings on coastal areas. These grasses should be native or well suited to the area in which they are planted. When the proper species are planted correctly, they are effective even against high-velocity winds heavily laden with sand. They are successful because (1) their coarse stems protect the surface against scouring; (2) they grow rapidly up through heavy deposits of sand, as much as 2 feet or more in a single season; (3) their stems multiply rapidly from underground nodes, forming large clumps; and (4) they develop extensive root systems and, in some cases, horizontal underground stems capable of growing into unvegetated areas and producing new clumps.

Initial stabilization of moving sand in the Pacific Northwest has been accomplished largely through the use of three sand-stilling grasses: European beachgrass, American beachgrass, and American dunegrass.

European beachgrass is the most widely used, primarily because its production costs are much lower, it transplants easily, and it has more vigorous top growth. Except for special uses that require American beachgrass or American dunegrass, European beachgrass should be used for initially stabilizing active dunes.

European beachgrass forms a tight cover where fertility is maintained by continual sand deposition. Healthy plants produce rhizomes up to 40 feet long in a single year.

European beachgrass has naturalized on the Pacific coast since it was introduced from Europe in the late 19th century to control sand dunes. It has coarse, stiff stems and tough leaves that resist sand blasting. Four different types occur naturally: Tall, coarse, and bunchy; tall, coarse, and creeping; short, fine, and bunchy; and short, fine, and creeping.

The best type for foredunes is tall, coarse, and creeping, although the other forms could be used, depending on the purpose. Tillering can vary from 10 to 120 per culm per year. The strain commonly used commercially tillers at a 40:1 rate.

European beachgrass requires a continuous supply of sand to provide nutrients, promote tillering and rhizome development, and maintain stands. Unless fertilized, plants receiving no new sand die out and are replaced by succeeding vegetation. European beachgrass produces numerous seedheads, a feature that has accelerated its naturalization along the Pacific coast and created the typical foredune landform so prevalent. However, direct seedings are not practical because seedlings develop too slowly to permit adequate ground cover in most cases.

American beachgrass, native to the Atlantic coast, is occasionally used to repair blowouts because of its ability to establish quickly and resist the border effect of competing vegetation.

Native American dunegrass has wider leaves and a darker lime-green color than European beachgrass. It can form complete cover on large foredune areas; however, it is more difficult to establish and usually increases through natural reseeding.

Despite variation within the species, there are no cultivars of European beachgrass and few commercial sources. Buyers usually should specify the tall, coarse, creeping type for most jobs.

American beachgrass use is limited to patching small blowouts and rarely for planting foredunes. It is strongly rhizomatous and competes well with European beachgrass. Newly planted American culms readily establish adjacent to well-developed European stands, primarily because of rapid rhizome development. Some American strains can produce close to 400 feet of rhizomes per plant per year, nearly 10 times as much as the better European strains.

American beachgrass persists where continual sand supply provides nutrients and is less likely than European beachgrass to survive when sand no longer accumulates. Although this plant is strongly rhizomatous, leaves and stems grow less rapidly than the European variety; therefore, American beachgrass does not control sand movement as well.

American beachgrass is native to the Atlantic coast and Great Lakes area. 'Cape,' a cultivar released by the Cape May (New Jersey) Plant Materials Center in 1971, originates from Cape Cod, Massachusetts, and performs well on the Pacific coast. However, it remains dormant longer than naturalized stands, creating a greater fire hazard. 'Hatteras,' a cultivar from North Carolina, may have shorter dormancy, but is untested on the Pacific coast. Naturalized tall, coarse, creeping strains are the source for nearly all plantings of American beachgrass in the Northwest. Naturalized stands are scarce and scattered along the Pacific coast, limited primarily to old planting sites. Commercial quantities therefore, are limited. American beachgrass is four times more costly to produce than European.

American dunegrass, previously the least planted of the three dunegrasses, is the only native dunegrass of the Pacific coast. Its main drawback is its low transplant survival, usually 25 percent or less, whereas 98 percent is essential for complete cover. In the past, plantings of this species have been limited to foredune areas, where it is found naturally. It also needs continuous sand supply to maintain stands and is less adapted than the beachgrasses to sites farther inland. Large natural stands are found in Clatsop County, Oregon, between Seaside and Warrenton, particularly near Sunset Beach. They seem to be increasing in recent years, supplanting European beachgrass. American dunegrass has wider leaves than the beachgrasses and often has an attractive lime green appearance, hence one of its common names, sea lyme-grass.

American dunegrass has increased in prevalence within foredune plant communities during recent years, particularly along the northern Oregon coast. It is often seen invading open sites and supplanting European beachgrass as the dominant vegetation.

American dunegrass must be transplanted while dormant to achieve the best establishment. This limits flexibility in planting, harvesting, and storing culms. Despite these limitations, interest in its use has increased in the past decade. Consideration should be given to including at least small amounts in mixture with European beachgrass.

Natural populations of American dunegrass on the Pacific coast have more pubescent seed heads and culms than the very closely related beach wildrye found along coastlines throughout the hemisphere at northern latitudes. These coastal dunegrasses are related to robust inland wildryes such as basin wildrye and Asiatic species, giant wildrye and altai wildrye. American dunegrass is known to hybridize with native inland creeping wildrye, forming smaller plants with finer leaves. Perhaps there are traits within this group of plants that can help overcome the obstacles to greater use of American dunegrass on the Pacific coast.

American dunegrass seedheads usually contain few viable seeds. This is an obligate cross-pollinating species and, since large colonies may consist of a single plant, low seed set is not surprising. Some populations have been found to have good seed set, undoubtedly due to the presence of many individuals. Plantings should include vegetative material from several sources to increase seed production.

Unsuitable Plants

Most of the native or naturalized colonizing plants abundant on coastal dunes in the Northwest are not alone satisfactory for controlling sand movement. Many have unwanted growth characteristics, are shortlived, and can be fire hazards. The most common of these plants are presented in table 1. Many invade naturally into beachgrass plantings and add some diversity and additional stability. But, unless specialized landscaping of small protected areas is desired, or an open, hummocky appearance is desired, planting of these species does not justify the expense.

Table 1.—Plants not recommended for controlling sand movement in coastal dune areas

Common Name	Problem
Baltic rush	Insufficient ground cover in winter
Beach knotweed	Hummocking, caused by taproot
Beach silver-top	Hummocking, caused by taproot
Big headed sedge	Insufficient ground cover in winter
Dune morning glory	Hummocking, caused by taproot
Sand verbena	Hummocking, caused by taproot
Seashore tansy	Insufficient ground cover in winter
Silver beach-weed	Hummocking, caused by taproot

When To Plant Sand-Stilling Grasses

European and American beachgrass and American dunegrass should be planted when temperatures are between 32 and 60 °F. No planting should be done unless moisture is found within a depth of 3 inches of the dune surface. Most plantings are made during the cool, wet months from late fall through early spring (November 1 to April 15).

Proper temperature is critical. Work done by Brown (1942) at the Warrenton Project indicates erratic survival rates if temperature exceeds 60 °F within a 72-hour period after planting. The effect of warm temperatures late in the planting season can be somewhat minimized by planting at night. All transplanting stock is either stored at 35 °F or shade frames are placed 12 inches above the tops of heeled-in culm bundles. If plantings must be made during warm daytime temperatures, then each bundle of beachgrass is dipped in water to keep it from drying out during the planting process. To ensure success and minimize planting costs, select planting dates well before warm spring days or well after cool fall temperatures have set in.

Planting is not done during freeze periods. Therefore, November, February, and March usually are the best months to plant.

Plantings are usually successful during cool weather in these 3 months, even without precipitation for prolonged periods. Low-lying sites that are moist into early summer may be planted more safely later in middle to late spring than the higher, drier sites.

Plantings for the construction of foredunes should be made in the early spring after danger from severe storms is over. Plantings made earlier can be destroyed by very high tides. Plantings made early in spring establish themselves before the warm weather and grow rapidly as new sand accumulates on the dune throughout the season. A good planting may accumulate as much as 2 feet of sand annually.

Areas that are subject to winter submergence should be planted in the spring as the water level recedes. Plantings that have not experienced one growing season fail to withstand extended submergence without damage.

Planting Stock

Commercial beachgrass stock may be obtained from nurseries or natural stands of proper age and quality. Nursery stock is dug at 2 years, and thus is designated "2-0" stock. Most natural stands will not produce quality stock; it is only

Shown here is a properly spaced planting of European beachgrass about 4 months after planting.

Beachgrass nursery stock usually originates from fertilized, relatively open, young stands where plants have room to grow and produce large, healthy culms.

where new sand deposits on existing grass are fertilized that quality stock is produced. This results in 1-0 (1-year-old) stock from plants buried the previous season. Quality planting stock consists of young, vigorous, live culms with one to three root nodes and a minimum of old, dead material. It is not possible to dig old stands because of the excessive cost of removing old dead parts of individual plants. Because of varying growing depths caused by new windblown sand deposits, no specific digging depth is recommended. The grass should be dug at a depth that will ensure that all culms have one to three live root nodes remaining.

After being dug, grass is shaken free of sand, dead trash is cleaned from culms, and the hill or clump is broken into small bunches. Underground stems are broken back to one or two nodes. For convenience in stock accounting and handling, culms are tied into bundles of 10 pounds. After tying, the tops of the stock are cut back with an ax until the overall length is about 20 inches. This gets rid of long leaves that offer more surface for moisture loss and that are subject to wind agitation that could loosen the planted stem from the sand.

In nurseries, stock can be dug each year if given an annual application of fertilizer. When properly fertilized, a new crop will come up from underground stems or rootstalks. Nursery areas can be 95 percent dug without damage to the vegetative cover. New culms quickly regenerate from rhizomes.

Stock is harvested during the planting season. Stock should be collected during the cool, wet months from late fall through early spring (November 1 to April 15), when the plant is most nearly dormant. American dunegrass must be harvested when completely dormant. Dormant stock will have the greatest amount of stored energy and will, therefore, be more vigorous than culms from plants that are actively growing. The beachgrasses (European and American), however, will survive whether or not they are dormant, as long as the stock is harvested and planted in cool weather.

Storing of grass stock is confined to "heeling-in" on the nursery or planting site. It is important when heeling-in to keep the beds narrow, not over two bundles wide, in order to avoid heating of the grass. Bundles should be buried in the trench to a depth of approximately one-half their length, and sand firmed around them. The grass should not be heeled-in where water will stand on the bed as this will cause decomposition of the basal buds of the stem. The heeling-in bed should be a well-drained, damp trench with the roots (nodes) covered to a depth of at least 8 inches. Stock should not be held in heeling-in beds for more than 2 weeks. If

A three-culm propagule is approximately 20 inches long.

planting is late in the season, then either shade frames over the heel-in beds or artificial cold storage at 35 °F is recommended.

Tools for Planting

The most widely used tool for handplanting of beachgrass is the D-handle tile spade with an 18-inch blade. This can be thrust directly to a depth of 12 inches into the sand and provides the best hole that can be achieved for easy planting of the beachgrass culms. Planters normally make several hundred holes with this tool before planting.

Steep slopes must be planted by hand. However, on the less sloping areas, transplanting machines have been used with success since 1960 for larger plantings of 5 acres or more from Santa Maria, California, to Westport, Washington (Ternyik 1979b).

The planting machines now used for large plantings are modified, commercial row crop transplanting machines. The planting shoe was redesigned to get the 12-inch depths specified for beachgrass plantings. Pulling these machines are small, crawler type tractors equipped with a rear-mounted hydraulic hitch. Two machines are now used behind each tractor, with four people on the machines. This combination will allow five people (including driver) to plant from 1 to 3 acres per day, depending on the conditions at the site. The primary conditions determining planting speed are weather, degree of slope, and type of sand.

Methods of Planting

Beachgrasses should be planted to a depth of 12 inches and the sand compacted to remove air around the roots and stem nodes. The top of the plant should be upright and extend approximately 8 inches above the ground.

Handplanting requires wet sand, otherwise holes are not open and the planters break the stock trying to force it into a closed hole. This results in high plant mortality. Transplanting machines can plant through 6 inches of dry sand. As a last resort, irrigation also can prepare a dry dune for planting.

For most sites along the Pacific coast, a hill spacing of 18 inches, with three culms per hill is sufficient. On sites exposed to more severe weathering, in areas surrounded by particularly valuable property, or on steep slopes or sand sea cliffs, closer planting with hill spacing approximately 12 inches and up to five culms per hill is needed. Well-protected sites can be stabilized by wider-than-normal spacings. A summary of planting rates that were found to be successful on the

A

B

C

A beachgrass hand-planting operation includes (a) opening a 12-inch-deep hole in wet sand with a tile spade, (b) placing a beachgrass propagule in the hole and leaving an 8-inch top, and (c) tamping sand around the propagule with the heel of a boot.

Clatsop Plains area are given in table 2. True economy in planting is achieved when hill spacing and the number of culms per hill are adjusted to the onsite conditions.

Fertilizing the Plantings

All planted areas should be fertilized with coarse-particle ammonium sulfate commercial fertilizer (N-P-K 21-0-0). This formulation should be applied at a rate of 42 pounds of available nitrogen per acre (200 pounds) during a period of light wind and steady rain. Rain is needed to thoroughly dissolve the fertilizer—a minimum of 4 hours of light rain or 2 hours of a downpour. If this is not done, fertilizer granules will be transported by winds, resulting in uneven distribution. Experience and weather forecasts are vital to ensure that the fertilizer is dissolved shortly after broadcasting. Irrigation may be substituted for rain, but usually is costly.

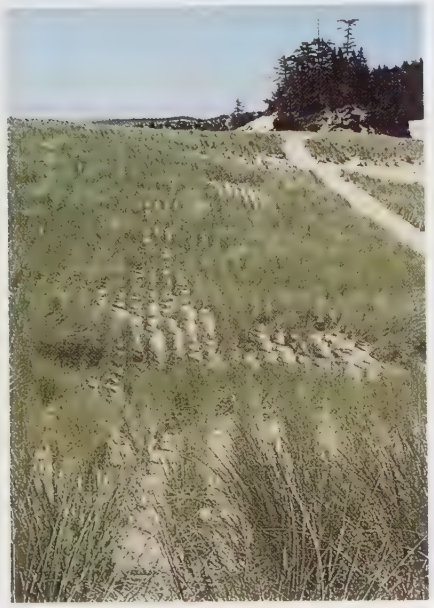
If the forward slope is steep or if sand sea cliffs have been planted, fertilizer must be applied immediately after planting so that it can be caught in the footprints left by the planting operation. If not, the fertilizer will filter to the bottom of the slope as the sand dries and no growth will occur on upper slopes. It is recommended that fertilizer application on these steep banks be

Until adequate tree growth results, beachgrass must be fertilized or interseeded with legumes to maintain adequate cover. Here a small bare area has appeared.

doubled to 400 pounds of N-P-K 21-0-0 per acre. If necessary, irrigate lightly and long enough to dissolve the fertilizer.

In cases where planting stock is scarce, the use of fertilizer on plantings with wider-than-normal spacing may be cheaper than deferring planting until more stock becomes available.

Followup fertilization on established plantings is best done on the Pacific coast dunes when the most rapid spring growth begins. In Washington, this is April 1 to April 15; in Oregon, it is March 1 to April 1; and in California, it is February 15 to March 1. There is usually plenty of moisture at these times and this permits the fertilizer to penetrate to the grass root system.



This site needs fertilizer to maintain adequate cover.

Most fertilizer is applied by hand, out of buckets, or with hand-operated cyclone type spreaders. This is because newly planted beachgrass is severely damaged by tractor-mounted spreaders. Two-year-old, well-established beachgrass plantings can be fertilized with tractor-mounted spreaders with little damage. Fertilizer usually is not spread by airplane unless the almost ever-present winds, which tend to drift the fertilizer, are absent.

Maintaining Dunegrass Stands

In this initial stage of dune stabilization it is important to develop and maintain an even vegetal cover that is devoid of breaks until secondary or permanent cover is established. Some maintenance is usually necessary because of poor hill survival, excessively wide spacing, or failure to plant all exposed areas. This requires temporary brush mats in summer and prompt replanting in the winter. American beachgrass is the most satisfactory plant for such repair work because it competes better than European beachgrass with surrounding European beachgrass systems (McLaughlin and Brown 1942).

Table 2.—Hill spacing and culms per hill for European beachgrass

Site conditions	High-intensity stabilization		Moderate-intensity stabilization	
	Spacing	Culms	Spacing	Culms
	Inches	*Number*	*Inches*	*Number*
Steep slopes				
Windward				
Dry	12 by 12	3	18 by 18	5
Moist	18 by 18	5	18 by 18	3
Leeward				
Dry	18 by 18	5	18 by 18	3
Moist	18 by 18	3	24 by 24	5
Flat areas				
Exposed to high winds				
Dry	18 by 18	5	18 by 18	3
Moist	18 by 18	5	18 by 18	3
Exposed to moderate winds				
Dry	18 by 18	3	18 by 18	5
Moist	18 by 18	5	24 by 24	5
Irregular topography				
Exposed to high winds				
Dry	12 by 12	5	18 by 18	5
Moist	18 by 18	5	18 by 18	3
Exposed to moderate winds				
Dry	18 by 18	5	18 by 18	3
Moist	18 by 18	5	18 by 18	3

Table 2.—Hill spacing and culms per hill for European beachgrass (Continued)

Site conditions	High-intensity stabilization		Moderate-intensity stabilization	
	Spacing	Culms	Spacing	Culms
	Inches	*Number*	*Inches*	*Number*
Valuable property				
Exposed to high winds				
Dry	12 by 12	5	12 by 12	3
Moist	12 by 12	3	18 by 18	5
Exposed to moderate winds				
Dry	12 by 12	3	18 by 18	5
Moist	12 by 12	3	18 by 18	5
Foredune*				
Windward face	18 by 18	3	-	-
Leeward face	18 by 18	5	-	-
Top	12 by 12	5	-	-

*All foredune areas are planted using the high-intensity approach.

Well-timed fertilization early in fall or in spring increases growth of low-vigor spots. A new planting should be checked at least monthly and after each major wind event to determine maintenance needs. A second-year planting should be inspected at least every other month.

Establishing and Maintaining a Source of Beachgrass

Unlike east coast nursery operations, where beachgrass is grown in cultivated fields, on the west coast it is grown in open sand. Carefully selected nursery sites are picked where

This large roadside cut and fill planting of European beachgrass near North Bend, Oregon, must be fertilized or interseeded with legumes to maintain adequate cover.

Above, vehicular and foot traffic should be controlled to protect beachgrass plantings that cannot withstand repeated trampling. Right, Douglas-fir and sitka spruce stumps can be used to protect plantings.

a continuing incoming sand supply is present. If new sand does not cover the nursery area, then a 3-year digging period is maximum. After the third season on such sites, the grass fails to meet specified size. One 100-acre planting will require 6 million culms of beachgrass. Therefore, identification of adequate-quality planting stock is essential. One commercial nursery in Florence, Oregon, maintains a 10- to 12-million in-field inventory of European beachgrass and 100,000 culm in-ground supply of American beachgrass and American dunegrass. The primary factor in nursery production is the ability to maintain vigorous, clean stands of grass requiring a minimum of cleaning during the digging process.

Permanent Cover

Shore lupine is a legume that often invades infertile sites where beachgrass has declined and sand deposition is not excessive. It is a prolific reseeder.

The main sand-stilling plants—European and American beachgrass and American dunegrass—begin to lose some of their vigor after a few years and it may be difficult to maintain cover. Dead stalks accumulate in the new growth, and some plants die. This causes the planted area to become patchy with open sand areas. Before this stage, it is advisable to ensure the development of a permanent cover by seeding longer lived grasses and legumes or by transplanting woody plants.

Species

Legumes help overcome the nitrogen deficiency of sandy soils, and thus help stimulate the growth of the grasses. Several species of legumes can be used. The most common are lupine, beach pea, perennial pea, and vetch.

Seashore lupine is a low-growing legume native to the dunes of the Northern Pacific coast. Its seeds germinate readily and the plants usually set a crop of seed the first season. In places, lupine develops so rapidly that it soon forms almost solid cover among the European beachgrass culms.

Purple beachpea is a fire-resistant legume and an excellent choice to seed into established beachgrass. It fixes nitrogen from the air and releases it for use by beachgrass.

Seashore lupine is short lived; thick initial stands steadily decline and seldom last 5 years. But, having increased the organic matter content and fertility of the soil, this plant leaves the ground surface in a condition suitable for establishing more permanent vegetation.

Purple beach pea produces more biomass than seashore lupine and is very fire resistant, an important factor to consider when interplanting beachgrass. It is slower to establish but more persistent, forming a thick viny growth. Stands usually are not fully developed until the third or fourth year after seeding. Seed and foliage are valuable to wildlife for food and cover. Beach pea, although not native, is found naturally along the coast from Alaska to California.

Unfortunately, seashore lupine and beach pea are not commercially available on a regular basis, and seed must be hand collected. This limits their use. Testing is underway to select and release cultivars of seashore lupine and purple beach pea for commercial production.

Recent evaluations at Ocean Shores, Washington, have compared the relative vigor of several commercially available legumes in areas stabilized with beachgrass. Perennial pea, pine lupine, and hairy vetch show the most promise as alternatives to seashore lupine and beach pea for large-scale seedings.

Perennial pea is slow in developing but persistent, with characteristics similar to beach pea. It is commonly found along roadsides farther inland, but can be established in beachgrass, though with less reliability.

Pine lupine is a robust, short-lived perennial native common to the coastal mountains of the Pacific Northwest. 'Hederma,' an improved cultivar, has shown promise on dredge spoils and stabilized coastal dunes.

Hairy vetch is a vigorous sprawling annual that reseeds sporadically, but can be used as a short-term planting to increase fertility. It is readily available commercially.

Scotch broom is a naturalized leguminous shrub. It is a vigorous and upright plant, reaching 6 feet, and offers resistance to fire in beachgrass plantings. Direct seedings are only sporadically successful but the plant should be transplanted. Scotch broom provides good wildlife food and cover and early wind protection for permanent tree and shrub plantings. However, scotch broom is considered by many to be an undesirable weed, particularly inland from coastal areas, where it may spread by seed to invade disturbed sites usually low in fertility and marginal for plant growth. Although it has many desirable characteristics and has been used extensively in the past, scotch broom seldom is interplanted into beachgrass-stabilized dunes today.

Tree lupine is a native leguminous shrub adapted to stabilized dunes

This mixture of beachpea and American dunegrass provides a cover that will not burn.

south of Newport, Oregon. It grows rapidly, gives excellent ground cover, and provides abundant litter for aiding fertility, but it may freeze out during severe winters. Plants can be found as far north as the central Washington coast, but losses resulting from freezing are more frequent in the northern reaches. Stands can be established by direct seeding, producing 4-foot plants after 2 years. Transplants have not been reliably established. Seed usually is not available commercially and must be hand collected.

Among native long-lived grasses that have been successfully seeded into initial dunegrass plantings are seashore bluegrass and red fescue. Seashore bluegrass withstands some sand deposition and survives under difficult conditions. It spreads rapidly by seed and by rhizomes that take root to form new plants. It is well suited to seeding, along with seashore lupine, into initial plantings of European or American beachgrass. Seashore bluegrass is not widely used because there is no commercial production and seed must be collected by hand. During the 1940's, a limited amount of seed from cultivated fields was produced on a trial basis near Astoria, Oregon. This species never advanced beyond this stage, giving way to red fescue, which could be readily supplied through the turfgrass trade.

Red fescue survives well in sand that is almost entirely stilled, but it cannot withstand sand deposition as well as seashore bluegrass. Nevertheless, fescue is widely used and covers large areas of coastal dunes, especially on drier sites. 'Clatsop' is a cultivar that was developed for sand dune seedings, but has not been produced for several years. Creeping red fescue, a rhizomatous form, is commercially available. 'Illahee' and 'Rainier' are adapted northwestern cultivars that can be used for permanent cover on sand dunes.

Tetraploid perennial ryegrass recently has been tested on sand dunes and dredge spoils. This species should form only a small percentage of a seed mixture because it may crowd out other species. It can be considered for quick short-lived cover while other, more persistent species develop. It has been seeded successfully alone for goose pasture on dredge spoils.

Another grass that has performed well recently on sandy dredge spoils is tall wheatgrass, which is very robust and tolerates saline conditions. Further testing may prove its adaptability on sand dunes.

Shrubs, in addition to the two woody legumes above, and trees can be successfully established in 2-year-old beachgrass/dunegrass stands. Shore pine is a small native tree that naturally invades newly stabilized dunes and can form dense thickets on deflation plains. It also is very easy to establish by transplanting and has been used extensively for permanent cover. After initial establishment, shore pine normally grows 2 feet per year on good sites. At the present time, shore pine is the most commonly used species for secondary stabilization.

Coyote brush is a native long-lived shrub that is transplanted into beachgrass plantings along the southern Oregon and northern California coasts. It forms a mounding cover. Prostrate to upright forms are available in the nursery trade. Container transplants are cuttings grown from male plants.

Other native woody plants can be used for permanent cover, particularly on wet sites. Red alder fixes nitrogen, grows rapidly, and gives way to climax species. It often volunteers naturally around deflation plains. However, high-velocity winds cause branch tips to burn back, limiting red alder's effectiveness in exposed areas. Hooker willow invades permanently wet sites. Its pliable stems and mounding habit also enable it to catch sand effectively. Plantings are easily established from hardwood cuttings stuck in permanently moist ground.

Oregon crabapple is native to the Pacific coast along riverbanks and lake shores. It is a long-lived tree that grows to 20 feet but in extreme wind can form a dense mat low to the ground. Fruits are readily eaten by birds.

Seashore bluegrass, a native perennial grass, can be interseeded in combination with legumes into beachgrass.

Autumn olive is an introduced shrub that has shown promise in recent tests on dunes stabilized by beachgrass. Although not a legume, it fixes its own nitrogen, and in the fall it produces an abundant crop of red berries that are relished by birds. The 'Elsberry' variety grows 6 to 8 feet high and to twice as wide, and appears to be well adapted to Pacific coast conditions.

Native Seed Harvest

Beach pea and lupine seed should be collected by hand because the seeds do not all ripen at the same time and natural stands usually are not of uniform density for economical mechanical harvesting. Pea moth infestations often destroy ripening seeds in both species. Pods should be collected after the seeds have begun to show a mottled color but before the pods dry and open. The pods should be spread on a canvas sheet to dry in the sun. They may also be dried by slight artificial heat. Seeds shatter out as the pods dry and open.

Collecting seeds of native grasses, such as seashore bluegrass, is laborious and expensive. On small lots it is easiest to strip the seed heads by hand or to clip them with a hand sickle. Occasional pure stands, covering a relatively large area, can be harvested with a mowing machine or a small combine. Seed is processed with conventional air-screen cleaners.

Planting Times and Seed Mixtures for Grasses and Legumes

It is best to defer permanent cover plantings until initial beachgrass plantings are 2 years old. The period when these plantings should be made will vary greatly under different conditions. However, it should not be delayed much after the sand is stilled, for two reasons: (1) vegetative competition from the initial plantings soon becomes too keen; and (2) as stands of beachgrass get older, sand can dry to a greater depth than young grasses and legume seedlings can tolerate.

Seeding may be done in the fall or early in the spring. Fall is preferred because legumes and grasses seeded in the spring often fail to germinate until the next fall. This is usually because of hard-seeded legumes or the lack of moisture.

The suggested seed mixture for drier sites is:

Species	Cultivar	Pounds/Acre
Seashore lupine	Native collection	5
Seashore bluegrass	Native collection	5
Purple beach pea	Native collection	20
Creeping red fescue	'Illahee,' 'Rainier'	12

Up to 30 pounds per acre of tree lupine may be added to this mixture.

If the lupine, bluegrass, and beach pea are not available, an alternate mixture of seed normally available on the commercial market can be used as follows:

Species	Cultivar	Pounds/Acre
Creeping red fescue	'Illahee,' 'Rainier'	12
Tetraploid perennial ryegrass	Locally adapted	3
Pine lupine	'Hederma'	20
Perennial pea	Commercial-common	20

Sand dune plant communities contain a diverse array of native and indigenous forbs, ground covers, and herbs. Shown here are beach morning glory (above top), sand knotweed (above, bottom), and wild strawberry (right). These plants generally do not have growth forms or root systems that enable them to be primary stabilization plants. Their presence as understory plants should be encouraged.

Substitutes include tree lupine for pine lupine or perennial pea, or hairy vetch for pine lupine. Both should be seeded at 20 to 30 pounds per acre.

Seeding Methods

Drill all seeds in order to cover them and to ensure uniform distribution. Rice hulls (obtained from California) should be used as a seed carrier to ensure even seeding through the drill when the mixture contains both large and small seeds. In irregular, rough areas the seeds should be broadcast. When seed is broadcast, mulching by clipping existing vegetation or by scattering straw or similar material greatly increases the chances for a successful even stand. All permanent seedings should be fertilized with 40 pounds of nitrogen and 80 pounds each of phosphorus and potassium per acre at the time of planting.

Fire Control

Care should be taken to plan for vegetative firebreaks in a woody habitat. Purple beach pea or scotch broom are green at the peak of fire season, and both are nitrogen-producing legumes, so grass cover mixed with them also tends to be green during this period. Racing fires seldom burn more than a few feet into either species.

Firebreak plantings should consist of interplanting beachgrass in 50-foot-wide bands interseeded with purple beach pea, at 20 lb/acre, or scotch broom, transplanted on 3-foot centers. Purple beach pea is well worth the expense of seed collection because of its superior fire-suppressing qualities. This legume also does not leave a large, lasting dry residue when it dies down in the fall.

Beachgrass will burn easily during the drier summer months, particularly older stands with a high percentage of dead stubble and chaff. Burns are common near parking lots and along roads.

Beachgrass plantings behind the foredune usually are planted to native shore pine. When the plantings are sufficiently tall and dense, they moderate wind velocities at the ground surface and control sand movement.

Shrubs and trees adapted to duneland immediately behind the foredune must be resistant to burning by wind. Shown here are shore pine, Oregon myrtle, and scotch broom. They are formed by the wind and conform to the landscape.

Woody Plantings

Shore pine usually is planted on 8-foot centers, between December and February after beachgrass plantings are 2 years old. It becomes the dominant vegetation after 10 to 12 years.

In most instances, woody plantings are made in place of permanent grass-legume seedings rather than in combination with them. Either way is acceptable, although combination plantings may result in thinner stands of woody plants. Often, it may be desirable to alternate herbaceous with woody plantings to increase diversity and create more edge for wildlife habitat.

Coyote brush, used from southern Oregon southward, transplants readily but is slower growing and therefore should be spaced closer together. It provides a low 2 1/2- to 3-foot high cover that supplants beachgrass in the interdune area and behind foredunes.

Besides providing a more stable cover, woody plantings also can "correct" uneven topography, reducing wind turbulence and eliminating wind tunnels. Both shore pine and scotch broom are resistant to wind. Shore pine especially becomes wind formed, conforming to the landscape.

Climax species such as sitka spruce and western hemlock are not planted on stabilized dunes because they volunteer readily into shore pine plantations. Douglas fir, although found naturally in some stabilized dune areas, is only marginally adapted. It tends to become wind damaged rather than wind formed.

Planting Methods

Shore pine, coyote brush, Oregon crabapple, and most other species are easily grown in nurseries. All stock should meet American Nursery Association's standards. All except shore pine should be planted as 1-0 seedlings to keep costs of large-scale mass plantings down. Shore pine should be 2-0 stock. Plantings from wildlings are not recommended because it is very difficult to dig up a sufficient root mass necessary for a high rate of transplant survival.

Broadleaf woody species should be 12 inches in height when transplanted. If taller, the tops are subject to wind burn during their establishment period. The minimum diameter of woody plants should be one-eighth of an inch measured at 1 inch above the root collar. Diameters of one-fourth of an inch are preferred because these plants will withstand more severe site conditions. All tips should be clipped back to about 12 inches in order to make planting easier.

The minimum-maximum range in height for shore pine or other conifers is 6 to 12 inches. The most convenient size for planting is 8 to 10 inches. Larger stock may be clipped to the desired height without detrimental effects if it meets all other specifications. Minimum diameter at the root collar is one-eighth of an inch; maximum diameter should be no more than three-eighths of an inch or the stock becomes oversized and hard to plant. The root system should be well branched and have many fibrous feeder roots. Broken roots should be trimmed.

It is essential that all broadleaf and coniferous stock meet minimum specifications, be dormant, and be free from disease and insect pests.

Stock from a distant nursery usually comes in some type of bale. If the weather is not too warm and the bales are kept in the shade, the stock is often so well packed that it can be kept in the bales for a week. However, it must be checked closely for signs of drying or exposure to damaging heat.

Under most conditions, stock should be removed from the bale and placed in "heel-in" beds in a shady place under moist conditions. When "heeling-in," the soil should be firmly packed about the roots, which should be kept straight. Soil around the roots should be higher than the ground line.

The tool used for planting most stock is the D-handle tile spade, which is the same tool used in beachgrass planting. When planting, soil should be firmly packed around the roots to prevent air pockets. Woody plants should be set in the ground to the same depth as they were in the nursery. This is especially important for coniferous stock because such species are intolerant of being buried to an appreciable depth. Willows, however, can be planted deeper in the field than in the nursery.

Roots must be kept moist and out of wind and sun. In the field, the stock should be kept moist and wrapped in burlap in a pail or in special carrying trays.

Most transplanting must be done from December to February, when plants are dormant, to optimize survival. Survival rate during this period has often been uniformly higher than 90 percent (Brown and Hafenrichter, 1962). Slow release fertilizer in each transplanting hole can boost initial plant growth.

Fire, rodents, and humans are the principal hazards to successful plantings of woody vegetation. Fire lanes through shore pine plantings are essential. Mice, beaver, and rabbits can easily damage young plantings but can be controlled, if necessary, with baits or other approved means. Vacationers and others frequenting recreation areas must be prevented from digging plants, creating fire hazards, and indiscriminately trampling and trailing.

Trees or other woody species should not be planted in the area immediately adjacent to open sand areas. In such areas, continually incoming windblown sand will kill them.

Maintenance

Fertilizer application of 100 pounds per acre of 16-16-16 N-P-K is recommended, as needed, to maintain stand vigor and growth of grasses and legumes. Managers should be ready each fall and spring to spot-fertilize weak areas as they are found during routine followup checks. Stand failures should be reseeded. Woody plantings seldom need fertilizer or other maintenance unless to increase their landscape value. Transplant failures should be replanted.

Temporary Mechanical Aids

Where applicable, suitable aids include sand fences, brush matting, oil, and wire netting, bark mulch, grass mats, rock gravel, clay, stone or concrete, and logs.

An important use of mechanical aids is to catch sand and shape dunes for future stabilization.

Sand fencing is perhaps the most common temporary stabilization method. It has been used on the Pacific coast to temporarily control large, windblown movements of sand from open dune areas or recently disturbed areas. Sand fences have also been used to create foredunes or to fill beaches.

Sand fences can be used in two important ways:

1. When located at right angles to the prevailing winds, they cause temporary deposition of sand.

2. When set at a tangent to the prevailing winds, they direct sand-laden wind and may, in some instances, result in a desired intensification of scouring.

Fence material ranges from individual pickets 1 to 4 inches wide to a wire and lath snow fence. The fences are most effective when placed in two parallel rows about 30 feet apart. Proper positioning is critical, because improperly placed fences can cause inundation of areas needing protection.

Supports for the fences should be installed by using heavy duty steel posts 6 feet long, driven into the sand 8 feet apart. The end posts should be anchored in three directions. The fence wire should be firmly attached to each post at the top, middle, and bottom.

Picket-type fences were used to build the foredune on the Clatsop Plains dune area. Two parallel lines of fence, 30 feet apart, were used to create the proper and stable conformation of this dune. The fences were made of pickets 4 feet tall, 4 inches wide, and three-fourths of an inch thick. It was essential to keep the top of the fence even so that the resulting dune would have an even crest. Unevenness of topography causes wind agitation around the high spots, which is detrimental to the success of the structure.

In some cases, fences have been used to raise roadbeds across soft, wet, deflation plains where equipment could not be used to do the job. The correct distance between fences depends on the size of sand particles and the mean wind velocity. When fences are spaced too far apart, two separate dune crests form. This is not desirable. When the fences are too close together, or a single fence is used, the result is a sharp crest that is difficult to establish to vegetation. Proper spacing of the fences results in the formation of a broad-based dune with a single, gently rounded crest.

Sand fences are the most common temporary mechanical aids in a dune stabilization system.

Fences should be used with caution. In some cases, fences 4 feet high, placed 30 feet apart across prevailing winds have filled in within 1 week. The lee side of such a fence will sometimes have 50 feet of sloping sand from accretion. Because of the rapid results achieved with fences, it is recommended that they be used only under the direction of experienced advisors.

Movable sand fences and brush barricades have been constructed for some control projects. The movable fences are similar to the old "A" style snow fence. Brush barricades can be constructed by weaving brush into wire and fastening them to posts at 10- to 12-foot intervals, or by digging a trench and burying the ends of the brush to form a dense barricade with the upper tip leaning away from the prevailing wind.

Fences and brush barricades are only temporary sand-stilling measures. They may be used to check the progress of sand only until it can be covered with the vegetation essential for permanent control.

Brush matting has been an accepted temporary measure since the early days of dune stabilization. It stops sand blowing, serves as a temporary check to further scouring, and acts as a mulch.

The brush, which can be reject material from coastal greenery trade, is laid flat on the ground. A second row is laid to partly overlap the first, shinglewise. On steep banks, the brush may be staked down and further secured by wire.

Matting is successful only if combined with a followup planting or a seeding of sand-stilling grasses or shrubs. In practice, it has been found very difficult to obtain a uniform stand of vegetation in this manner. Spots not fully protected by the permanent species can be scoured by the wind as the mat deteriorates.

Asphalt oil is used as a stabilizer on cut slopes associated with highway or railroad construction. It is strictly a temporary measure and is easily destroyed by human or animal activity. Also, it is unsightly, costly, and can make it difficult to establish permanent plant cover.

At The Dalles, in interior Oregon, attempts were made to stabilize a 100-acre active dune using oil. After two attempts and several years' time lapse, the oil coating deteriorated and the dune area doubled in size. It was later totally covered with an expensive gravel blanket. Failure at any portion of an oil-treated area can result in rough, uneven terrain. This results in increased cost of followup stabilization.

Chicken wire netting is normally used to hold down either brush or straw matting on steep slopes. Wire can be used during the summer, when vegetative planting efforts are not feasible. It is also an effective method for obtaining immediate relief from wind erosion. The wire must be laced together and staked down at 10-foot intervals to be effective.

In recent years, fir or hemlock bark has been used for temporary stabilization. Bark is expensive, but it is much more tolerant of foot traffic than rock and is attractive. It also prevents loss of moisture from the underlying sand. Bark is available in several sizes, ranging from coarse bark rock to finely ground mulch. Bark rock should be used in areas of strong wind exposure, and bark mulch should be used in back or protected areas.

In using bark:

A. The entire area to be treated must be covered, particularly along the windward edge. Bare spots will scour and may cause a complete blowout.

B. The bark should be at least 5 feet from all wooden structures, as it can pose a significant fire hazard.

C. Unperforated plastic sheeting should not be placed beneath bark, for two reasons. First, bark is buoyant and the heavy winter rains will displace it. Second, bark will slide down a plastic sheet on a slope, especially in the rain.

A straw mat or ryegrass straw can be placed on the ground surface on a calm day with no wind. On large areas, the straw is punched into the sand with a sheepfoot roller or large farm disc. On cut banks, or areas of extreme wind exposure, wire netting may be used to secure the straw. Permanent grasses and legumes can be seeded directly into the straw cover in the fall.

Rock or gravel can be used to prevent wind scouring, but in areas of heavy rainfall it is easily buried. It can, however, serve as a firebreak in residential areas, as it will not ignite from a carelessly thrown cigarette.

Clay is used to bind the sand and prevent wind erosion. This is costly and likely to have a very temporary beneficial effect.

Seawalls of stone or concrete can prevent sand from moving inland. If the source of the sand is extensive, however, dunes big enough to inundate the seawall will soon develop.

Beach logs can be used for stabilization. The weight of the logs prevents natural slumping on slopes, but if large voids exist between the logs, vegetation should be planted.

Landscape Plants for Stabilized Dunes

Once coastal sand dunes are stabilized with primary and secondary vegetation, certain land uses, such as urban development or recreation, may demand more intensive landscaping of the stabilized area. If sufficient organic matter, fertilizer, mulch, and supplemental water are provided, most plants adapted for landscaping of inland coastal sites, such as rhododendrons and azaleas, can be grown on stabilized dunes. However, these amendments in the amounts required can be very expensive to apply and maintain on coarse dune sand. There are some species, mostly natives, that can be found on older stabilized dunes, that are preferred landscaping choices.

Ground Covers

Shrub species in this group are decumbent, creeping, or low and dense. They are long lived and fire resistant.

Salal is a decumbent evergreen shrub that roots at the nodes, spreads rapidly, and forms a dense mat on the surface of the soil. It is widely distributed along the coast and grows in dense shade and partial sun. It is wind resistant. Salal grows best on well-drained sites but can be used where the soil is wet but not ponded. Seedlings are easy to grow from seed, and they transplant readily. Aside from making an ideal ground cover under climax trees, salal has utilitarian values. The fruit can be used for jelly and as food for game birds, and the foliage is valued for florist greenery.

Kinnikinnick (also called bearberry) is a creeping evergreen shrub that roots at the nodes and makes a good ground cover in partial shade, especially at the edges of open areas in tree plantings. It requires well-drained sites but, once established, spreads rapidly. Planting stock can be grown from seed but is easily obtained from cuttings. The fruit of kinnikinnick provides food for wildlife.

Douglas spiraea, or hardhack, makes a low, dense thicket on the poorly drained swampy areas within the dune area. It is a long-lived deciduous shrub, is very resistant to fire, and produces enough sprouts to completely cover the area. It will not tolerate shading. Plantings can be made with nursery-grown seedlings, but, as coastal dune areas become stabilized, it quickly volunteers on wet sites if plants are growing near the area.

Coyote brush, described earlier, also is a useful ground cover for more intensive landscaping.

Medium Shrubs

Shrubs in this group should be shade tolerant, evergreen, long lived, and fire resistant.

Evergreen huckleberry occurs naturally as an understory in forest vegetation on stabilized dunes on the coast. It is easily established with nursery-grown stock and attains a height of 4 to 5 feet in about 5 years. Well-drained sites are required for good establishment and optimum growth. This shrub produces good crops of edible berries that are used both for human consumption and as food for wildlife.

Pacific wax myrtle can be used on sites that are intermittently wet or have a high water table. It is best adapted to the southern half of the northern Pacific coast. Foliage is glossy, attractive, and wind resistant. Fruits are purplish nutlets and used by birds.

Scotch broom and autumn olive, described earlier, can be used for landscaping, as well as stabilization plantings. Both fix their own nitrogen and require less maintenance than typical landscape species. There are many ornamental varieties of scotch broom, providing a wide choice of flower colors.

Evergreen blackberry is exceptionally well adapted to the dune areas along the northern Pacific coast. It is a vigorous, spiny, decumbent evergreen shrub that produces abundant crops of edible fruit. Because of the growth characteristics and the spines, evergreen blackberry can be used to prevent indiscriminate traffic into areas planted to permanent trees. This plant is easy to establish from seedlings or crown divisions and is long lived. Some consider it to be too weedy.

Native salmonberry and thimbleberry volunteer and grow naturally as erect border plants on both well-drained and poorly drained sites. They provide food and shelter for upland game birds and are lightly browsed by deer. Twinberry honeysuckle, a viny shrub, is similar to these two shrubs in adaptation, establishment, and use.

Trees

Shore pine, described earlier, is an excellent landscaping choice for a conifer in coastal areas. Oregon crabapple is also an attractive small deciduous tree.

Four native timber species also can be planted on landscaped, stabilized dunes, but generally require mature, well-stabilized sites for optimum performance. They are Sitka spruce, which tolerates strong winds and wind forms in exposed areas; western hemlock; western red cedar; and Douglas fir, which probably is the least desirable of the four for landscaping on dunes because it is susceptible to wind damage.

The species described above represent the best-performing of over 50 native and introduced woody plants which have been evaluated in a long-term adaptation test plot trial near Astoria, Oregon. This test plot trial, established in the late 1930's, can still be visited today by contacting the local Soil Conservation Service office.

Marsh Habitats for Wet Interdune Areas

Description

Deflation plains, created when the wind-blown beach sand supply is cut off by foredune development and sand on the lee side is scoured down to the water table, usually revegetate naturally in a relatively short period to marsh plants. Common invaders include slough sedge, rushes, Pacific silverweed, and numerous other forbs. However, since deflation plains often are formed during the building of a foredune with beachgrasses, they usually are planted as well to suitable cover or improved waterfowl food.

Species and Mixtures

A standard seed mixture for deflation plains consists of a cereal grain and common pasture species:

Barley and tetraploid ryegrass germinate and develop very rapidly following seeding. Tall fescue and trefoils are more persistent, will begin to take over during the second year, and can provide a long-lasting cover.

Where maximum waterfowl food is desired, deflation plains can be annually seeded to barley at 100 pounds (2 bushels) per acre and fertilized with at least 60 pounds per acre N-P-K, usually 15-15-15 or similar analysis. Barley is the preferred cereal grain because of its greater tolerance to salty or brackish conditions.

Increasingly, deflation plains or other coastal areas that are tidally influenced are established to prime native marsh habitat. Such plantings may be part of a mitigation of lost estuarine plant communities resulting from dredge spoil deposition,

Species	Cultivar	Pounds/Acre
Barley	Locally adapted	100 (2 bushels)
Tetraploid ryegrass	Locally adapted	5
Tall fescue	'Alta,' 'Fawn'	20
Birdsfoot trefoil	'Kalo,' 'Cascade,' 'Viking,' 'Empire'	4
Big trefoil	'Marshfield'	2

Deflation plain wetlands and estuaries are extremely valuable for waterfowl and other forms of wildlife. Their conservation and reclamation are high priorities in most coastal community plans.

harbor development, or other activity. A generalized intertidal coastal marsh (Boss 1981) in the Pacific Northwest consists of three zones: low marsh, high marsh, and transition (to upland) zones. Indicator plants for the low marsh are arrow grass, pickleweed, and lyngby sedge. High marsh indicators include saltwort, tufted hairgrass, and creeping spike rush. Transition zone species include Pacific silverweed, redtop, and Baltic rush.

Despite the large number of marsh plants that are prevalent, only a few species to date have been successfully established in revegetation

Creeping spike rush is another useful fresh water marsh species. It is easily established and quickly forms a good cover.

projects. The following recommendations are based on testing by Ternyik (1980) for sites along bays and rivers that are tidally influenced:

Low Marsh:	Lyngby sedge
High Marsh:	Slough sedge
	Tussock
	Sharp-fruited rush
	Tufted hairgrass
	Creeping spike rush

All marsh plants are transplanted rather than seeded. The recommended species are dug from their natural habitat. Dug plants are separated into 4 to 7 culm sprigs; tops are cut back to 8 inches and roots to 6 inches. Processed sprigs are stored in ventilated plastic containers placed in holes dug in the upper one-third of the tidal range. Plants should not be stored longer than 7 days. Dry roots or broken stems result in low survival, so plants in this condition should be rejected.

Sprigs are planted on 18-inch centers with rows offset and parallel to the water's edge. Planting depth is 6 inches, but a hole is dug deep enough to prevent J rooting and backfilled firmly to prevent floatouts. A planted sprig should be upright with the top 8 inches above ground.

Planting occurs after tidal waters have been off the surface for 1 hour. Temperatures during planting must be below 65 °F and above freezing. Machine planters are rarely used but are feasible if care is exercised not to destroy the benthic community.

Slough sedge is one of several important wetland species that can be easily established in a marsh reclamation project.

Hooker willow quickly invades deflation plains and is considered somewhat weedy by many. However, its tough, pliable stems make it valuable for plantings along coastal streams, and it can withstand sand deposition.

Interest is building for creating artificial tidal mudflats that support eelgrass in mitigating the loss of these environments elsewhere.

Cover for Dredge Spoils

Ship channel dredging is an ongoing activity in major rivers emptying into the ocean along the Pacific Northwest coast. Dredge spoils usually are placed on undredged portions of the river, often in estuarine zones, and can cover large areas. Left to revegetate naturally, wind erosion causes the coarse-textured spoil to migrate from the site. Artificial revegetation usually is necessary.

Approach

If shaped properly, a dredge spoil can be turned into marsh habitat, a stabilized upland site, or a mixture of the two. Marsh plants should be planted in intertidal zones as described in the previous section.

Upland sites are stabilized using the species and techniques for treating sand dunes described earlier with some modifications. Beachgrasses should be planted on areas that are subject to severe blowing. For instance, dredge spoil islands on the Columbia River often are planted to beachgrass along the windward, western edge toward the ocean, to trap sand blowing inland.

Because the "beach" along dredge spoil islands is usually degrading, wave action encroaches on the protective beachgrass strip. Therefore, the beachgrass strip should be wide enough and may need to be planted further inland until permanent vegetation becomes established.

Small dredge spoils may be planted entirely to beachgrass, but larger areas usually are direct seeded to permanent grasses and legumes on a prepared seedbed, except for the protective beachgrass strip around the edges.

Species

Many of the same species used for sand dune seedings can be used for upland dredge spoil sites. Recent tests have shown that tall wheatgrass and sickle-keeled lupine are especially well suited for upland dredge spoil seedings. Tall wheatgrass has excellent seedling vigor, and is tall, robust, and salt tolerant, with good wildlife cover value.

Pine lupine also has excellent seedling vigor, is robust, and provides large amounts of nitrogen to the sterile dredge material. 'Hederma,' a recent cultivar, has performed very well on several dredge spoil sites from Coos Bay, Oregon, to Ocean Shores, Washington.

Mixtures

Upland dredge spoil sites should be seeded to the following seed mixture:

Species	Cultivar	Pounds/Acre
Tall wheatgrass	'Largo'	20
Creeping red fescue	'Illahee,' 'Rainier'	8
Pine lupine	'Hederma'	20

If tall wheatgrass is unavailable, tetraploid ryegrass may be substituted at 10 pounds per acre. Creeping red fescue is readily available. Hairy vetch, tree lupine, or perennial pea may be substituted for pine lupine in order of decreasing preference.

Marsh creation recommendations should be followed where dredge spoils are formed to support wetland habitats. Woody plants, if desired, are those recommended previously for dune plantings.

Seedings should be drilled whenever possible. However, barging seeding equipment to dredge spoil islands may not be feasible and seed must be broadcast. If so, seeding rates should be increased by 50 percent as the chance of failure is substantially greater.

Seedings are best done in the late summer or fall, September 1 through October 15, but are possible in the early spring, March 1 through April 15. Fertilizer is essential at time of planting at a 40-80-80 N-P-K rate. If the legumes establish successfully, followup fertilization may not be necessary. Sites subject to severe blowing should be mulched with cereal straw or, as a last resort, grass hay which usually contains large amounts of weed seed. Straw mulch should be punched into the spoil with suitable equipment.

Case History: Warrenton Dune Control Project

The most complete and extensive dune control project along the west coast of the United States is the Warrenton Dune Control Project on the Clatsop Plains (Warrenton Dune SWCD, 1970). In 1935, more than 3,000 acres of active, moving sand dunes in the northwest corner of Clatsop County, Oregon, at the mouth of the Columbia River, were threatening adjoining farmland, forests, lakes used for recreation, and navigational channels.

Beach erosion, aggradation, and dune formation are nothing new or unique to the Pacific Northwest coastline. Hanson (1947) suggests that there has been very little permanent stabilization of the coastline in the past 6,000 years when the coastline reached its current level following the last ice age. Prior to settling by humans, fire was a major cause of disturbance and contributed to the cyclic pattern of dune formation and stabilization by vegetation. Shore pine is a prominent species that has adapted through time to constant coastal dune disturbance and stabilization process.

Fire has been increasingly controlled since humans have inhabited the coastline. However, logging, cultivation, grazing, jetty construction, and other activities have significantly affected beach sand supply and dune formation. A combination of these factors caused the formation of extensive, active, moving dunes on the Clatsop Plains in 1935.

Prior to 1885, a 20-foot-deep ship channel was maintained at the mouth of the Columbia River through the sand bars that formed as sand was carried down the river. After 1885, jetties were constructed, eventually extending 7 miles on the south and 3 miles on the north side of the river. By 1935, the river channel had scoured to a depth of more than 45 feet, depositing sand along the coast on both sides of the mouth. To the south, a low-lying sand flat was formed one-half mile wide at the jetty gradually narrowing and extending down the beach several miles. These jetties were one main source of sand that created the dunes and their movement that reached critical levels in 1935.

If beaches are formed gradually, natural vegetation often keeps pace helping to build littoral dunes that reduce dune activity inland. In the case of the Clatsop Plains, the beach by the jetty increased too rapidly for vegetation to keep pace, although European beachgrass had been

On the left is a plank road that led to the Peter Iredale Shipwreck in 1937. On the right the same location 52 years after it was planted to beachgrass and shore pine (Clatsop County, Oregon).

naturalized in the area for 30 years. As a result, there was a huge sand supply for massive dune formation inland that threatened the established land uses along the coast.

The other major cause of the sand dune problem on the Clatsop Plains was overgrazing. Widespread grazing by cattle, horses, and sheep in the early 1900's created trails in the stabilized dune sand, causing blowouts. By 1935, an estimated 40 million cubic yards of sand had blown inland from the old foredune that extended from the mouth of the Columbia River to Tillamook Head. The foredune was almost completely destroyed.

In 1935, landowners and the Clatsop County government decided to stabilize the 3,000 acres of active sand dunes and return the land to more productive use. The first work was accomplished by the Civilian Conservation Corps (CCC). Twenty-three miles of sand fences were installed and all open sand areas were planted to European beachgrass. The foredune was completely reestablished. In the less erosive areas behind the foredune, grasses and legumes were seeded into the beachgrass for permanent cover. Native shore pine and scotch broom were extensively planted over the entire area. Essentially the same procedures described previously in this publication were used to complete the project. In fact, the experience gained during this project provides the basis for most recommendations today.

By 1941, most of the 3,000 acres had been stabilized, at least initially. In that year the Warrenton Dune Soil and Water Conservation District, a local unit of government, was formed by area landowners to provide for wise land use and development of the stabilized area. The district, with technical assistance from the Soil Conservation Service, administered further planting projects and provided for maintenance of the planted dunes. Because of the original severity of the dune activity prior to 1935, the district established an ordinance to enforce proper land use for the area. The ordinance remains in effect today.

Specifications for Contracts

Written specifications are developed for most of the larger stabilization jobs and are required when governmental agencies are involved, no matter the size. Specifications are tailored to the specific job, but must contain certain elements. Following are the recommended specification outlines for vegetative practices:

Dunegrass planting for initial stabilization
Scope of work
Site preparation including mechanical aids
Type, source, and quality of planting stock
Digging, stripping, and trimming method
Storage method
Transportation and handling
Planting method
Fertilizer application
Inspection and replanting
Measurement and payment

Grass-legume seeding for permanent stabilization, including dredge spoil or deflation plain seedings
Scope of work
Seed quality
Seed mixture
Seeding method
Fertilizer application
Inspection and reseeding
Measurement and payment

Woody planting for permanent stabilization
Scope of work
Species, type, and quality of planting stock
Transportation and handling
Planting method
Fertilizer application
Inspection and replanting
Measurement and payment

Landscape plantings
Scope of work
Site preparation
Species, type, and quality of planting stock
Transportation and handling
Topsoil mixture and amendments
Planting method
Mulch
Irrigation
Inspection and replanting
Measurement and payment

Marsh habitat planting
Scope of work
Site preparation
Type, source, and quality of planting stock
Digging and trimming method
Storage method
Transportation and handling
Planting method
Fertilizer application
Inspection and replanting
Measurement and payment

Contracting representatives responsible for inspecting plantings should check no less than 5 percent of the area treated. Except for very large jobs, a much larger percentage of the area is usually inspected for compliance with the specifications. Generally, plantings can tolerate a 10-percent transplanting or stand failure unless failure is concentrated in one or two locations within the planting. Failures between 5 and 10 percent should be reflected in a corresponding reduction in payment to the contractor. Failures greater than 10 percent must be replanted by the contractor.

Labor and Equipment Requirements

Hours of labor and equipment use vary with site conditions and density of planting. However, table 3 provides some general outputs for various tasks.

Summary of Recommended Plant Material

Table 4 summarizes plant species recommended in preceding chapters by ecological type, planting stock, adaptation to dune area, availability, planting rate, and season. Table 5 provides numbers of transplants needed for various plant spacings.

Table 3.—Time requirements or work rates for three types of dune stabilization tasks

Type of work	Spacing	Rate
Plant dunegrasses (or marsh plants)	12 inches	320 hr/acre 136 hills/hr
	18 inches	128 hr/acre 150 hills/hr
	24 inches	72 hr/acre 150 hills/hr
Seed grasses and legumes into dunegrasses, or on deflation plains or dredge spoils, with a 6-foot drill.		2.5 hr/acre (labor) 1.2 hr/acre (equipment)
Plant woody seedling transplants on stabilized dune area.		100 plants/hr
	3 by 3 ft	49 hr/acre
	6 by 6 ft	12 hr/acre
	8 by 8 ft	7 hr/acre
	12 by 12 ft	3 hr/acre

Table 4.—Basic recommended plant material for dune stabilization

Species	Type	Planting Stock						Adaptation					Availability	Planting Rate	Planting Season
		BR	B&B	Seed	1-0	2-0	Size	FD	MH	OS	SD	DS			
Grasses															
European beachgrass	IS	x				x	20"	x		x		x	CA	18"x18"	Nov. 15-Mar. 15
American beachgrass	IS	x				x	20"	x		x			CA	18"x18"	Nov. 15-Mar. 15
American dunegrass	IS	x				x	20"	x					CA	18"x18"	Nov. 15-Mar. 15
Creeping red fescue	PC			x							x	x	CA	12 lb/acre	Sept. or Apr.-June
Seashore bluegrass	PC			x							x	x	FC	5 lb/acre	Sept. or Apr.-June
Tall wheatgrass	PC			x							x	x	CA	20 lb/acre	Sept. or Apr.-June
Tetraploid ryegrass	PC			x							x	x	CA	3 lb/acre	Sept. or Apr.-June
Barley	IS			x			x						CA	100 lb/acre	Sept. or Apr.-June
Tall fescue	PC			x			x						CA	10-20 lb/acre	Sept. or Apr.-June
Legumes															
Hairy vetch	PC			x							x	x	CA	20 lb/acre	Sept. or Apr.-June
Perennial pea	PC			x							x	x	CA	20 lb/acre	Sept. or Apr.-June

*Abbreviations defined on page 47.

Table 4.—Basic recommended plant material for dune stabilization (Continued)

Species	Type	Planting Stock						Adaptation					Availability	Planting Rate	Planting Season
		BR	B&B	Seed	1-0	2-0	Size	FD	MH	OS	SD	DS			
Purple beachpea	PC			x							x	x	FC	20 lb/acre	Apr.-June
Seashore lupine	PC			x							x	x	FC	51 lb/acre	Sept. or Apr.-June
Pine lupine	PC			x							x	x	CA	20 lb/acre	Sept. or Apr.-June
Tree lupine	PC			x							x	x	FC	30 lb/acre	Apr.-June
Birdsfoot trefoil	PC	x							x				CA	41 lb/acre	Sept. or Apr.-June
Big trefoil	PC	x							x				CA	21 lb/acre	Sept. or Apr.-June
Marsh															
Creeping spike rush	HM	x					12"		x				FC	18"x18"	Apr.-July
Lyngby sedge	LM	x					12"		x				FC	18"x18"	Apr.-July
Sharp-fruited rush	HM	x					12"		x				FC	18"x18"	Apr.-July
Slough sedge	HM	x					12"		x				FC	18"x18"	Apr.-July
Tufted hairgrass	HM	x					12"		x				FC	18"x18"	Apr.-July
Tussock	HM	x					14"		x				FC	18"x18"	Apr.-July

Abbreviations defined on page 47.

Table 4.—Basic recommended plant material for dune stabilization (Continued)

Species	Type	Planting Stock						Adaptation					Availability	Planting Rate	Planting Season
		BR	B&B	Seed	1-0	2-0	Size	FD	MH	OS	SD	DS			
Woody															
Autumn olive	PC	x			x	x	12" (6')				x	x	CA	6'x6'	Dec.-Mar.
Kinnikinnick	L					x	1 gal (1')				x		CA	3'x3'	Dec.-Feb.
Coyote brush	PC	x			x		1 gal (2')				x	x	CA	3'x3'	Dec.-Feb.
Douglas spiraea	L	x			x		1 gal (5')				x		CA	3'x3'	Dec.-Mar.
Evergreen blackberry	L	x			x		1 gal		x		x		CA	6'x6'	Dec.-Feb.
Evergreen huckleberry	L	x					1 gal (5')				x		CA	3'x3'	Dec.-Feb.
Oregon crabapple	PC		x		x	x	1 gal (15')			x	x		CA	6'x6'	Dec.-Feb.
Red alder	PC	x				x	12" (60')				x	x	CA	8'x8'	Dec.-Feb.
Salal	L					x	1 gal (4')				x	x	CA	3'x3'	Dec.-Feb.
Hooker willow	PC	x			x		18" (10')		x				FC	3'x3'	Nov.-Apr.
Salmonberry	L				x		12" (6')				x		CA	6'x6'	Dec.-Feb.
Scotch broom	PC	x			x		12" (6')				x	x	CA	8'x8'	Dec.-Mar.
Shore pine	PC	x	x			x	12" (50')				x	x	CA	8'x8'	Dec.-Feb.
Sitka spruce	L	x	x			x	12" (80')				x		CA	8'x8'	Dec.-Feb.
Pacific wax myrtle	L		x			x	1 gal (10')				x	x	CA	8'x8'	Dec.-Feb.
Western hemlock	L	x	x			x	1 gal (80')				x		CA	8'x8'	Dec.-Feb.

*Abbreviations defined on page 47.

Abbreviations for Table 4

B&B - balled and burlapped
BR - bare root stock
CA - commercially available
DS - open sandy dredge spoils
FC - field collection
FD - foredune or frontal areas
HM - high marsh
IS - colonizer-initial stabilizer
1-O - 1-year-old seedling
2-O - 2-year-old seedling
L - landscape plant
LM - low marsh
MH - deflation plain, wet interdune, or marsh habitat
OS - open sand dunes including blowouts
PC - permanent cover
SD - stabilized dunes and spoils container size
Size - height or container size

Table 5.—Transplants needed with varied space requirements

Transplant Type	Spacing	1,000 sq.ft.	1 Acre	100 Acres
Beachgrass				
3 culms/hill	12" x 12"	3,004	130,680	13,068,000
3 culms/hill	18" x 18"	1,335	58,080	5,808,000
3 culms/hill	24" x 24"	751	32,670	3,267,000
3 culms/hill	30" x 30"	480	20,880	2,088,000
5 culms/hill	12" x 12"	5,006	217,800	21,780,000
Woody species				
1 transplant/hill	3' x 3'	111	5,840	584,000
1 transplant/hill	6' x 6'	28	1,210	121,000
1 transplant/hill	8' x 8'	16	680	68,000
1 transplant/hill	12' x 12'	7	302	30,200

Note: A word of caution—always order 3 percent more to offset heavy planting.

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Glossary

active dune A dune with little or no vegetal cover, and which is subject to movement by the action of the wind.

benthic A plant or animal living in or on the bottom of a body of water.

blowout A scoured out gap in vegetation caused by wind-blown sand; wind-blown sand buries and kills vegetal cover.

climax species In any given region there is a succession of plant species toward a type adapted to withstand even the extremes of local climate. Climax vegetation is relatively stable.

clone Several attached culms.

culm Single-jointed stem of a grass.

deflation plain A flat area of sand that is normally east of the foredune and scoured by the wind down to the summertime water table.

foredune The dune closest to the high-tide line that extends parallel to the beach. The foredune can be divided into three sections: the frontal area (closest to water); the top surface; and the lee or reverse slope (back side).

heeling in A technique for storing plant stock in temporary plantings as in a nursery.

inner or open dune area Open areas of actively blowing sand no longer receiving sand from ocean beaches.

pioneer or colonizer The first few plants to establish themselves in an area.

prograding A coastal area which is increasing in shoreline area, through the addition of sand or other sediment, at the expense of the area occupied by the sea.

retrograding A coastal area that is eroding. The shoreline opposite of a prograding shoreline.

stable dune A dune that changes slowly over time. Stable dunes have adequate vegetal cover and this protects against the blowing of a massive amount of sand off the dune.

subclimax species Species of plants that will be replaced by others in succession.

succession A sequence of vegetal changes whereby one type replaces another until a climax species or group of species is reached.

volunteer species Native plant species whose seed invades natural or artificially stabilized areas of sand.

wet interdune Areas of sand between dunes that are subject to seasonal flooding or periodic tidal area flooding, but not affected by the beach sand supply.

wind formed Plants that bend, over time, with the wind without suffering serious damage.

wind tip Wind blows down vegetation or bends it to the point of destruction.

Appendix I

Common and Scientific Plant Names Used in This Publication

Recommended Plants

Grasses:

American beachgrass — *Ammophila breviligulata* Fern.
American dunegrass — *Leymus mollis* (Trin.) Pilger
Barley — *Hordeum vulgare* L.
European beachgrass — *Ammophila arenaria* [L.] Link.
Seashore bluegrass — *Poa macrantha* Vasey
Tall fescue — *Festuca arundinacea* Schreb.
Tall wheatgrass — *Thinopyrum ponticum* (Podp.) Barkw. & D.R. Dewey
Tufted hairgrass — *Deschampsia cespitosa* [L.] Beauv.

Sedges/Rushes:

Creeping spike rush — *Eleocharis palustris* [L.] Roem. and Schult.
Lyngby sedge — *Carex lyngbyei* Hornem.
Sharp-fruited rush — *Juncus acuminatus* Mich X.
Slough sedge — *Carex obnupta* L.H. Bailey
Tussock — *Juncus effusus* L.

Legumes:

Big trefoil — *Lotus uliginosus* Schkuhr.
Birdsfoot trefoil — *Lotus corniculatus* L.
Hairy vetch — *Vicia villosa* Roth.
Perennial pea — *Lathyrus latifolius* L.
Purple beach pea — *Lathyrus japonicus* Willd.
Seashore lupine — *Lupinus littoralis* Dougl.
Tree lupine — *Lupinus arboreus* Sims.

Woody Plants:

Autumn olive — *Elaeagnus umbellata* Thunb.
Bearberry — *Arctostaphylos uva-ursi* [L.] Spreng.
Coyote brush — *Baccharis pilularis* DC
Douglas-fir — *Pseudotsuga menziesii* [Mirb.] Franco.
Douglas spiraea or hardhack — *Spiraea douglasii* Hook.
Evergreen blackberry — *Rubus laciniatus* Willd.
Evergreen huckleberry — *Vaccinium ovatum* Pursh.
Hooker willow — *Salix hookerana* Barr.
Kinnikinnick — *Arctostaphylos uva-ursi* [L.] Spreng.
Oregon crabapple — *Malus fusca* [Raf.] Schn.
Pacific wax myrtle — *Myrica californica* Cham.
Red alder — *Alnus rubra* Bong.
Salal — *Gaultheria shallon* Pursh.
Salmonberry — *Rubus spectabilis* Pursh.
Scotch broom — *Cytisus scoparius* [L.] Link.
Shore pine — *Pinus contorta* Loud.
Sitka spruce — *Picea sitchensis* [Bong.] Carr.
Thimbleberry — *Rubus parviflorus* Nutt.
Twinberry honeysuckle — *Lonicera involucrata* [Rich.] Banks.
Western hemlock — *Tsuga heterophylla* [Raf] Satg.
Western redcedar — *Thuja plicata* Donn.

Other Plants Listed

Altai wildrye — *Leymus augustus* (Trin.) Pilger
Arrowgrass — *Triglochin maritimum* L.
Baltic rush — *Juncus balticus* Willd.
Basin wildrye — *Leymus cinereus* (Scribn. & Merr.) Love
Beach knotweed — *Polygonum paronychia* C&S
Beach silver-top — *Glehnia leiocarpa* Math.
Beach wildrye — *Leymus arenarius* (L.) Hochst.
Big headed sedge — *Carex macrocephala* Willd.
Creeping wildrye — *Leymus triticoides* (Buck.) Pilger
Dune morning glory — *Convolvulus soldanella* L.
Giant wildrye — *Leymus racemosus*
Gorse — *Ulex europaeus* L.
Pacific silverweed — *Potentilla anserina*, subsp. *pacifica* (T. Howell) Rousi
Pickleweed — *Salicornia virginica* L.
Redtop — *Agrostis alba* L.
Saltwort — *Glaux maritima* L.
Sand verbena — *Abronia latifolia* Esch.
Seashore tansy —*Tanacetum camphoratum* Less.
Silver weed — *Franseria chamissonis* Less.

Appendix II

Beaches and Dunes Site Investigation Checklist

(Excerpted from Nelson 1976)

Location:

1. Local Zoning Regulations
   Does the proposed development site plan conform to city or county zoning regulations regarding setback lines and other code provisions? (Contact the city or county engineer for details.)
   ☐ Yes ☐ No

2. Comprehensive Plan Setback Line or Destination
   a. Has a Coastal Construction Setback Line (CCSBL) been adopted for this county or city? (Ask the county or city engineer.)
      ☐ Yes ☐ No
   b. Is the proposed site seaward of the CCSBL?
      ☐ Yes ☐ No
   c. If the proposed site is seaward of the CCSBL, has application for a variance or exception been made to the planning commission having jurisdiction?
      ☐ Yes ☐ No

3. Identified Hazardous Conditions
   a. Has any portion of the property been identified as being affected by any potential or existing geological hazard? (Contact county or city planning departments for information published by the State department of agriculture, Soil Conservation Service, U.S. Geological Survey, U.S. Army Corps of Engineers, and other government agencies.)
      ☐ Yes ☐ No
   b. Are any of the following identified hazards present?
      1. Active foredune
         ☐ Yes ☐ No
      2. Water erosion
         ☐ Yes ☐ No
      3. Wave undercutting or wave overtopping
         ☐ Yes ☐ No
      4. Flooding
         ☐ Yes ☐ No
      5. Wind erosion, scour
         ☐ Yes ☐ No
      6. Landslide or slough activity
         ☐ Yes ☐ No
   c. Are there records of these hazards ever being present on the site?
      ☐ Yes ☐ No

4. Existing Site Vegetation
   a. Does the vegetation on the site adequately protect against soil erosion from wind and surface water runoff?
      ☐ Yes ☐ No
   b. Does the condition of vegetation constitute a possible fire hazard or contributing factor to slide potential? (If answer is "yes," full details and possible remedies will be required.)
      ☐ Yes ☐ No

5. Fish and Wildlife Habitat
   a. Does the site contain any identified rare or endangered species or unique habitat (feeding, nesting, or resting)?
      ☐ Yes ☐ No
   b. Will any significant habitat be adversely affected by the development? (Contact State fish and wildlife department or county and city planning staffs for inventory data.)
      ☐ Yes ☐ No

6. Historical and Archaeological Sites
   Are there any identified historical or archaeological sites within the area proposed for development? (Contact local planning office.)
   ☐ Yes ☐ No

7. Flood Plain Elevation
   a. Does the elevation of the 100-year flood plain or storm tide exceed the existing ground elevation at the site? (Contact the Federal Insurance Administration, city or county planning departments for information on 100-year flood plain. Site elevations can be identified by local registered surveyor.)
      ☐ Yes ☐ No
   b. Will the lowest habitable floor of the proposed development be raised above the top of the highest predicted storm-wave cresting on the 100-year flood or storm tide?
      ☐ Yes ☐ No

8. Condition of Adjoining and Nearby Areas

Are any of the following natural hazards present on adjoining or nearby properties that would pose a threat to this site?

a. Open dunes
☐ Yes ☐ No

b. Active foredunes
☐ Yes ☐ No

c. Storm runoff erosion
☐ Yes ☐ No

d. Wave undercutting or wave overtopping
☐ Yes ☐ No

e. Slide areas
☐ Yes ☐ No

f. Combustible vegetative cover (Contact county and city planning staffs for local hazard information.)
☐ Yes ☐ No

9. Development Effects

a. Will there be adverse offsite effects as a result of this development?
☐ Yes ☐ No

b. Identify possible problem type:

1. Increased wind exposure
☐ Yes ☐ No

2. Open sand movement
☐ Yes ☐ No

3. Vegetative destruction
☐ Yes ☐ No

4. Increased water erosion (storm runoff, driftwood removal, reduction of foredune, etc.)
☐ Yes ☐ No

5. Increased slide potential
☐ Yes ☐ No

6. Effect on aquifer
☐ Yes ☐ No

c. Has landform capability (density, slope failure, ground water, vegetation, etc.) been a consideration in preparing the development proposal?
☐ Yes ☐ No

d. Will there be social and economic benefits from the proposed development?
☐ Yes ☐ No

e. Identified benefits:

1. New jobs
☐ Yes ☐ No

2. Increased tax base
☐ Yes ☐ No

3. Improved fish and wildlife habitat
☐ Yes ☐ No

4. Public access
☐ Yes ☐ No

5. Housing needs
☐ Yes ☐ No

6. Recreation potential
☐ Yes ☐ No

7. Dune stabilization (protection of other features)
☐ Yes ☐ No

8. Other

10. Proposed Design

a. Has a site map been submitted showing in detail exact location of proposed structures?
☐ Yes ☐ No

b. Have detailed plans showing structure foundations been submitted?
☐ Yes ☐ No

c. Have detailed plans and specifications for the placement of protective structures been submitted if need is indicated?
☐ Yes ☐ No

d. Has a plan for interim stabilization, permanent revegetation, and vegetation maintenance been submitted?
☐ Yes ☐ No

e. Is the area currently being used by the following?

1. Off-road vehicles

☐ Yes ☐ No

2. Motorcycles

☐ Yes ☐ No

3. Horses

☐ Yes ☐ No

f. Has a plan been developed to control or prohibit the use of off-road vehicles, motorcycles, and horses?

☐ Yes ☐ No

11. Oregon Land Conservation and Development Commission (LCDC) Coastal Goal Requirements

a. Have you read the LCDC goals affecting the site? (Contact LCDC city or county office for copies of goals.)

☐ Yes ☐ No

b. Have you identified any possible conflicts between the proposed development and the goals or acknowledged comprehensive plan? (If so, list them and contact local planning staff for possible resolution.)

☐ Yes ☐ No

c. Have all Federal and State agency requirements for consistency been met? (Contact local planning office.)

☐ Yes ☐ No

d. Has applicant or investigator determined that the development proposal is compatible with the LCDC beaches and dunes goal and other appropriate statewide land use planning laws?

☐ Yes ☐ No

United States
Department of Agriculture

P.O. Box 2890
Washington, D.C. 20013

OFFICIAL BUSINESS
Penalty for Private Use $300

SOURCE - DON LEACH, SOIL CONSERVATION SERVICE DIST. CONSERVATIONIST 1965-88.
ASTORIA, OR - 861-1680 (NOW NAT. RESOURCES)

1933 35 - CCC moved in 1935, camped at Warrenton. Most men were from the South (LA. GA. TENN). Came in to stabilize dunes at the jetty. Went as far as the N end of Surf Pines (Camp Rilea) which was got property. Fort Stevens was county - Rilea was state

Dates?

Barney Lucas owned the land south of Rilea. He went to Jewell to get lumber from state-timber land to cut stakes for the picket fences for the fore dunes (largest next to shore). CCC also got American & European beach grass and set up a 5 acre nursery to develop the grasses before planting. At the South end there were some native grasses that cattle grazed on.

In the early 1900's there were "poptrains" that came down each summer that met their families to have beach parties. These parties had bonfires on the beach which created a fire hazard, eventually burning the native grass. Horses had also grazed on the land, and fox hunts added to the destruction by trampling the grass.

CCC worked on both state and private lands. Soil Conservation district was formed with Barney Lucas which agreed to stabilize the dunes Norm Yeon, Malarkey, & Manion (Father owned Oregon Realty).

TREES: hemlock ash spruce shore pine

Soil Erosion Service did the engineering work and provided plants, (Knickinick), grass and trees, with CCC providing labor. The private landowners had to pay for planting and construction. Thought CCC did the work.

(the local Soil/Cons. district was formed and took over so that the project could be free to all. Under a state can to ask for federal help?)

Referrals:

Tom Davis, ST John Portland.

Paul Lee, geologist, surf pines

SOURCE: WILBUR TERNYIK, CONSULTANT FIELD CONSERVATIONIST,
WAVE BEACH GRASS NURSERY - Box 1190, Florence, OR 97439
PHONE: 1-541-997-2401

GREAT GRANDFATHER: SOLOMON SMITH, came to Oregon, married an Indian woman, grandfather was JW Wallingford, police chief of Warrenton. GREW up in Warrenton.

Ternyik, while in high school, got 7 5¢ per 1,000 trees planted. Usually could plant 2,000 a day ~~after school~~ He was hired by Bryson Lausch, Soil conservation service (Dept of agri.). also hired by Barney Lucas when he was off duty, to plant in Surf Pines. The trees were grown in Beecnigham Plant Materials Nursery. Robert Brown of the State Soil Cons. expected a 50% mortality so ~~plants~~ trees were planted 3ft apart. Got 100% success.

Ternyik claims the opossums came into the state with the CCC boys from the South, who brought them for pets. Never had any in Oregon before that time.

Waterhouse was a loggers and owned timberland. Owns property in Surf Pines and south to Bearhart ~~farm~~ Old Ray Rd.

Seeds from local trees were collected by Ternyik and others, sent to Beecnigham to grow, then sent back down to plant, so are native to area. 1,000's of scotch brooms were also planted.

The land was grazing land - grass was "belly high" to a horse. The jetty caused extreme (?) erosion so the foredunes were built by using picket fences.

Ternyik now consults for ~~corporation~~ countries all over the world because of the success of controlling dunes with plant material.

ELDON WRIGHT - NATURAL RESOURCES # GEARHART (Volunteer)
9-1 M-F TOOK OVER WARRENTON DUNES DIST. 738-5680
325-4571 - office -
Bill EAGLE - NRCS . part staff - 397-4545 . once a week in office
Surf Pines was pasture and grazing land.

Beach pea - legume and European Beach Grass planted to provide nitrogen.

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(dicyclomine
hydrochloride USP)

FROM DON LEACH

on target
when painful spasm
is the presenting
symptom in the irritable
bowel syndrome*

1933-35 - CCC mined in 1935
camped @ Warrenton - most from
South - (La Ga) came in to stabilize
dunes at the jetty - came down to
N end of surf pines (Camp Rilea)
worked on public lands - FT - (county)
Camp Rilea (state) -

Barney Lucas owned land - PUBLIC LAND south from
present to Jewel to get timber from
state timber land to cut stakes
for picket fences for foredunes.

CCC also get American -
European beach grass - and
set up 5 acre nursery
to ed help -

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(dicyclomine hydrochloride USP)

*This drug has been classified "probably" effective in the treatment of functional bowel/irritable bowel syndrome and infant colic.

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(dicyclomine hydrochloride USP)

on target when painful spasm is the presenting symptom in the irritable bowel syndrome*

There were native grasses that cattle grazed on in South end.

"Positrani" in 1900's – came down in summer – had beach parties created fire hazards on beach – burned grass. Horses also grazed on land – fox hunts trampled grass

CCC worked on St. & Fed. lands. Soil/Cons. formed with Barney Lucas to agree & stabilize dunes. Norm Young, Carl, Macarkey, Marvin (father had Ore. Realty)

Soil Erosion Service was did engineering work – provided plants, grass, trees

CCC did labor

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